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**Gomes et al.**

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(54) **DISTRIBUTED SEMICONDUCTOR DIE AND PACKAGE ARCHITECTURE**

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See application file for complete search history.

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(21) Appl. No.: **16/902,123**

(57) **ABSTRACT**

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The present disclosure is directed to systems and methods of conductively coupling a plurality of relatively physically small core dies to a relatively physically larger base die using an electrical mesh network that is formed in whole or in part in, on, across, or about all or a portion of the base die. Electrical mesh networks beneficially permit the positioning of the cores in close proximity to support circuitry carried by the base die. The minimal separation between the core circuitry and the support circuitry advantageously improves communication bandwidth while reducing power consumption. Each of the cores may include functionally dedicated circuitry such as processor core circuitry, field programmable logic, memory, or graphics processing circuitry. The use of core dies beneficially and advantageously permits the use of a wide variety of cores, each having a common or similar interface to the electrical mesh network.

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**Related U.S. Application Data**

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(51) **Int. Cl.**

*H01L 25/18* (2006.01)

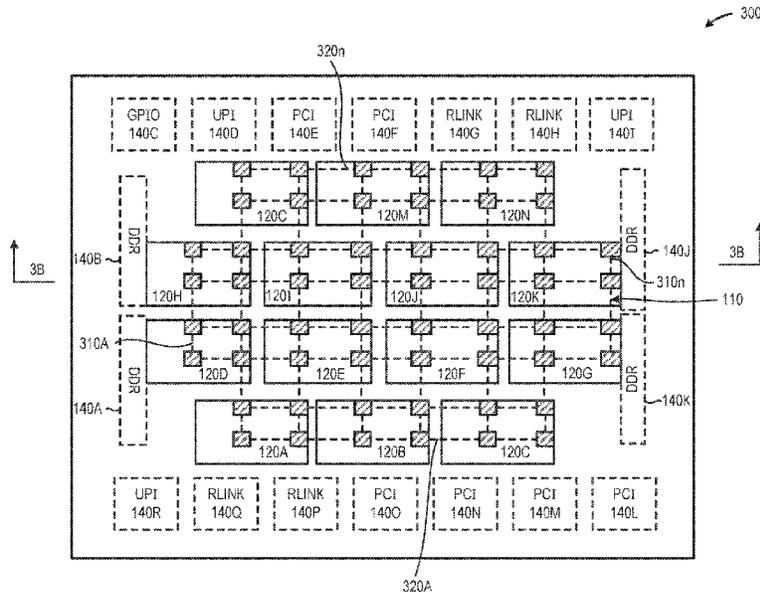
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(Continued)

(52) **U.S. Cl.**

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**12 Claims, 11 Drawing Sheets**



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*H01L 23/00* (2006.01)  
*H01L 23/538* (2006.01)  
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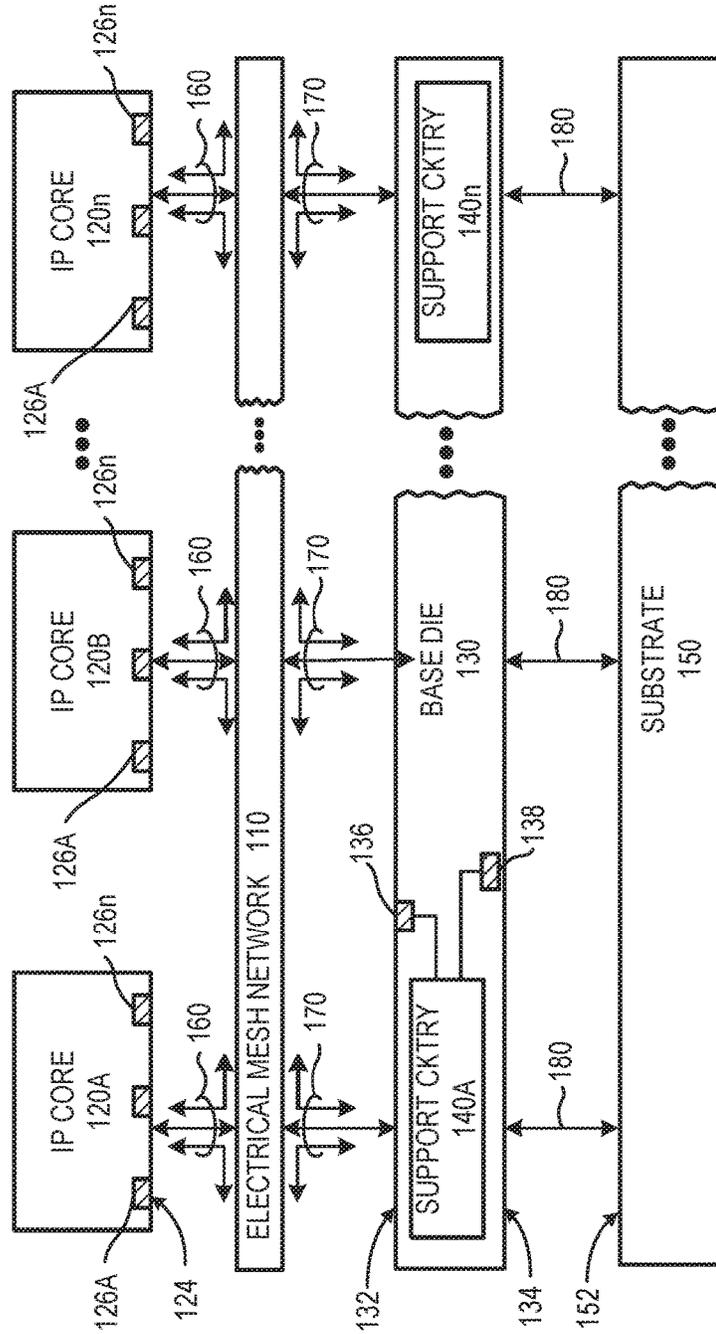


FIG. 1

200

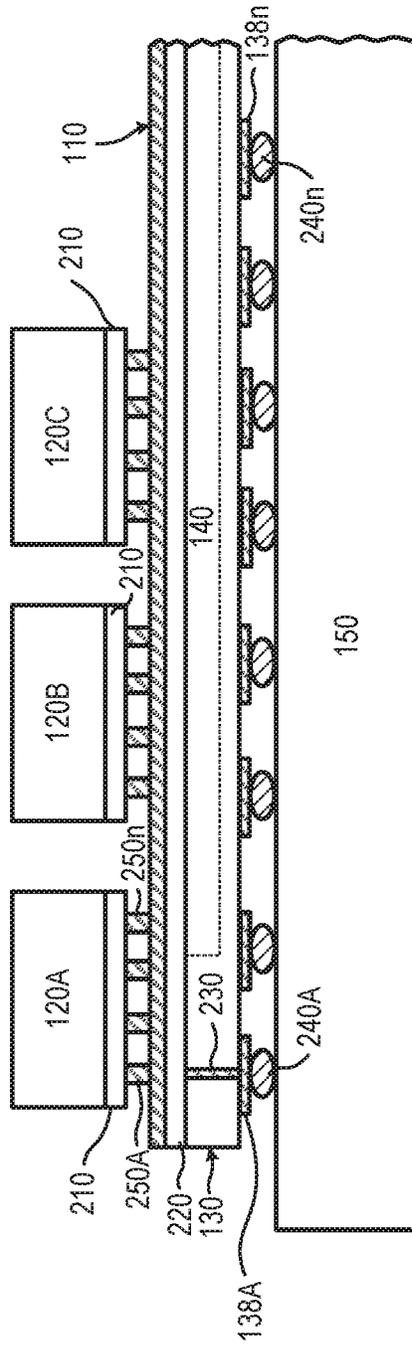


FIG. 2



300

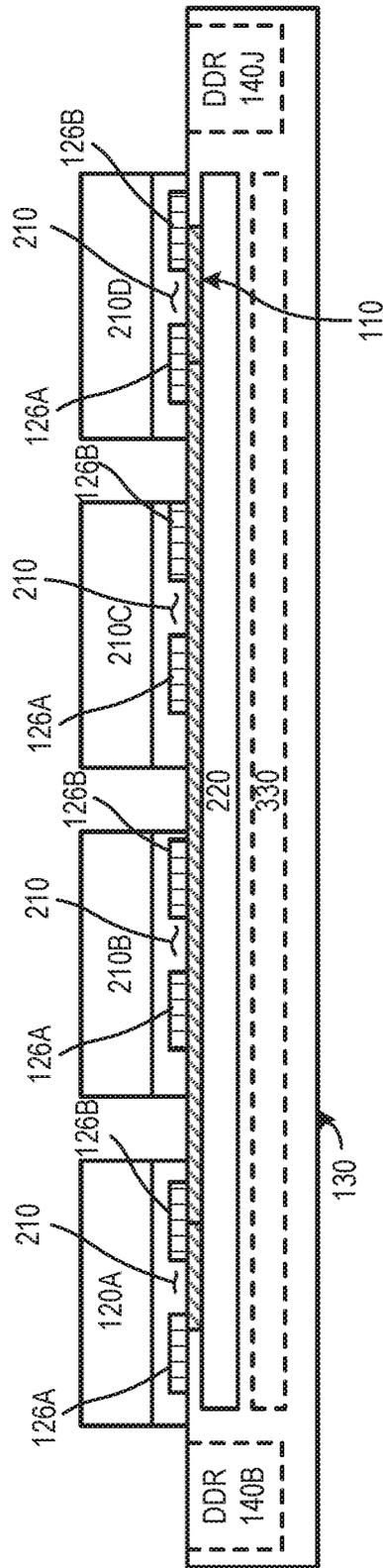


FIG. 3B

400

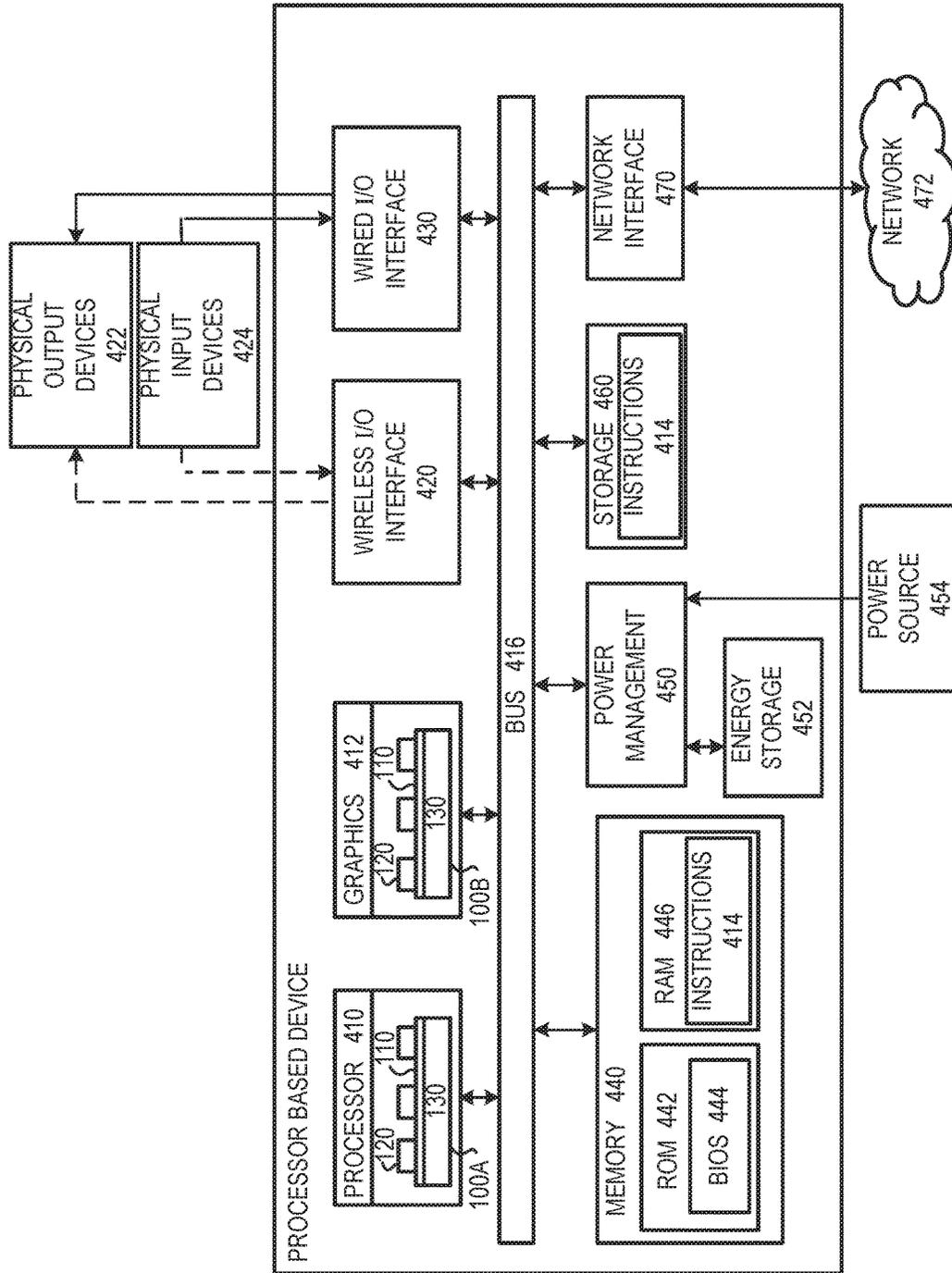


FIG. 4

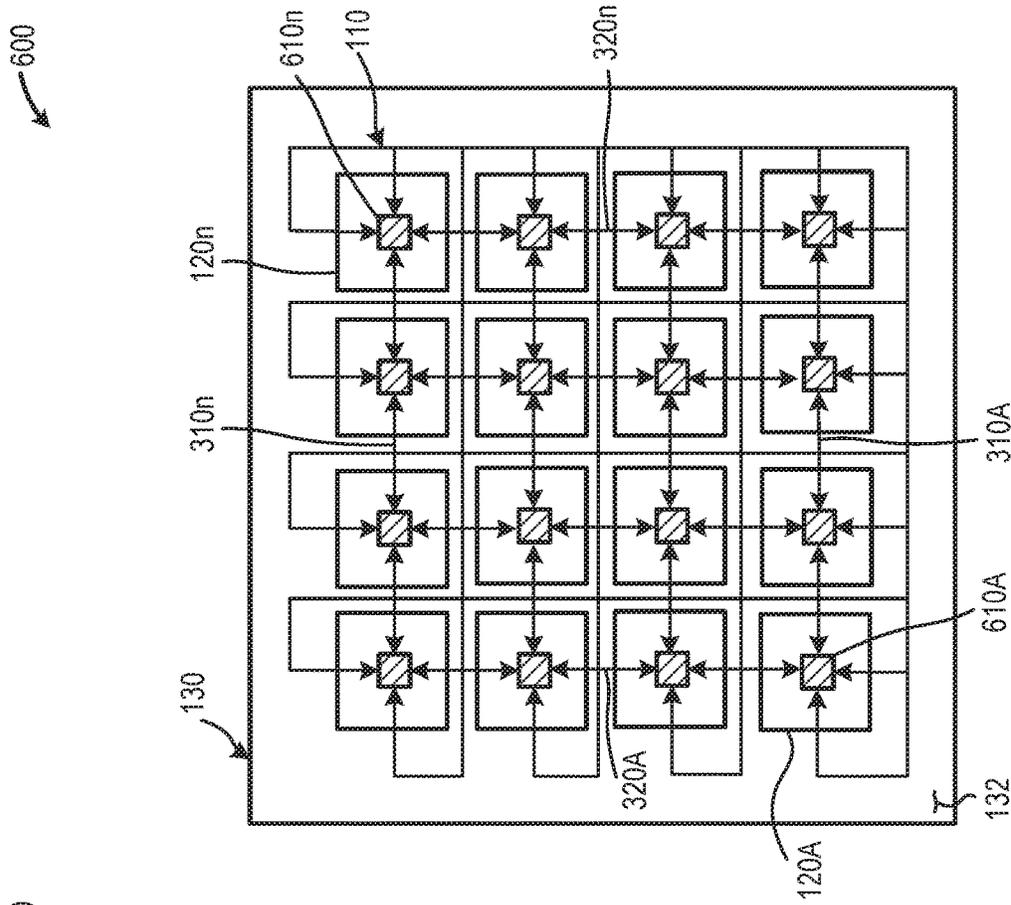


FIG. 5

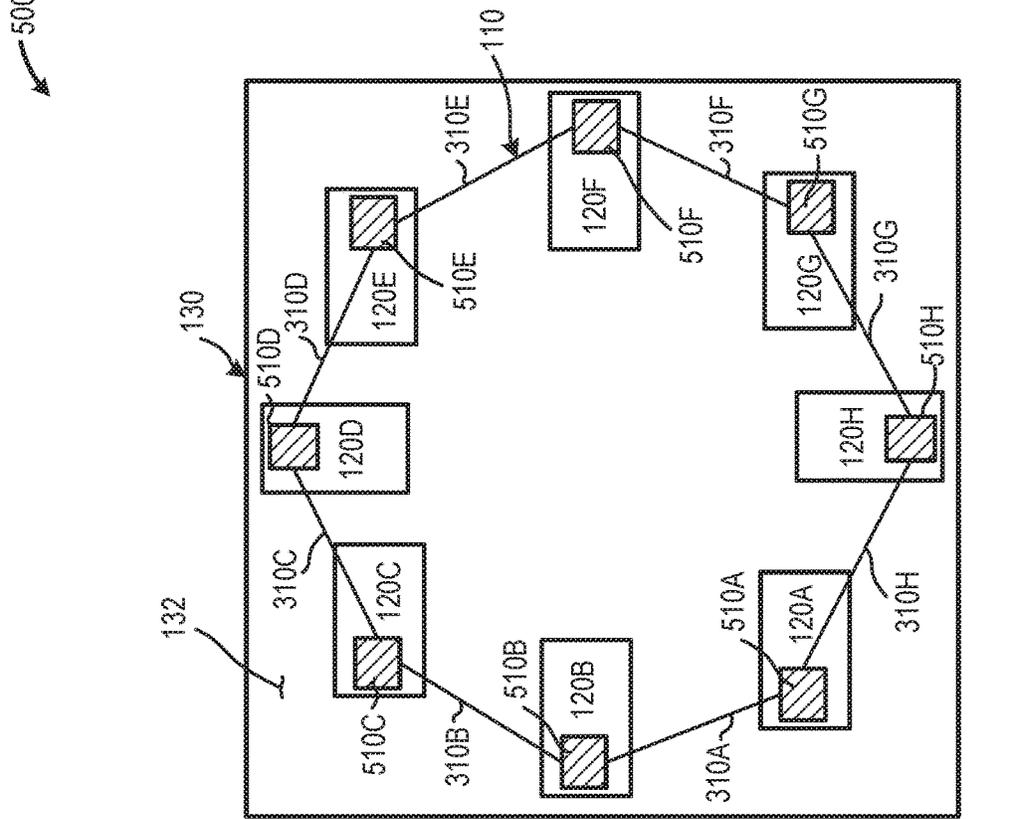


FIG. 6

700

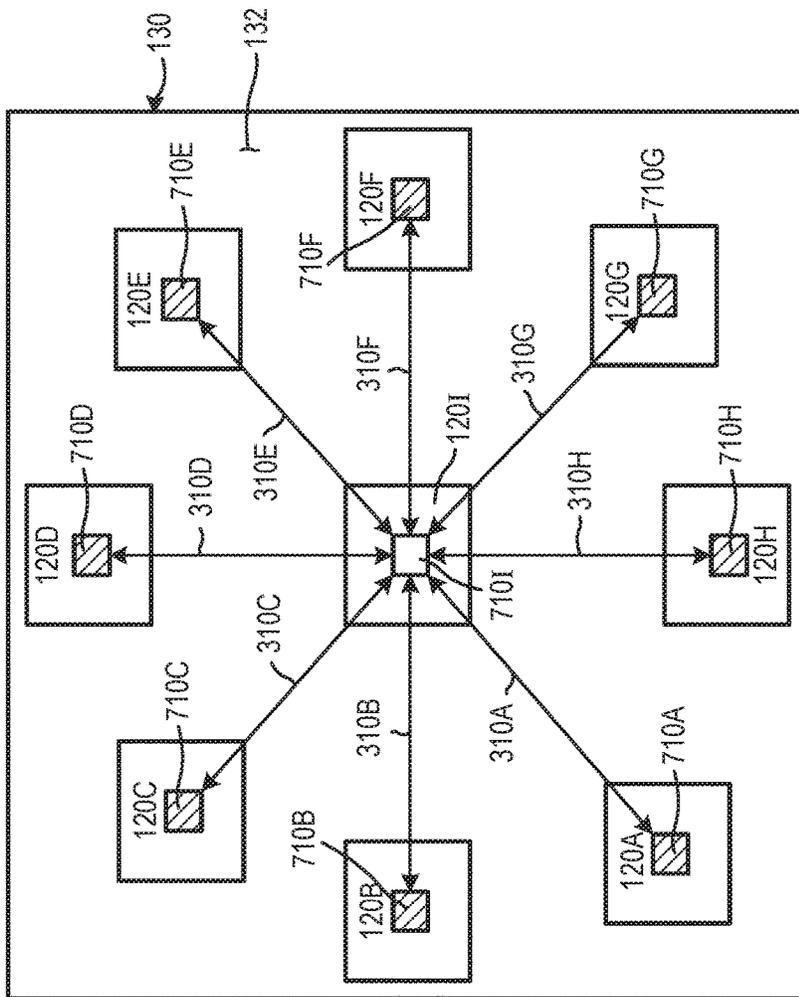


FIG. 7

800

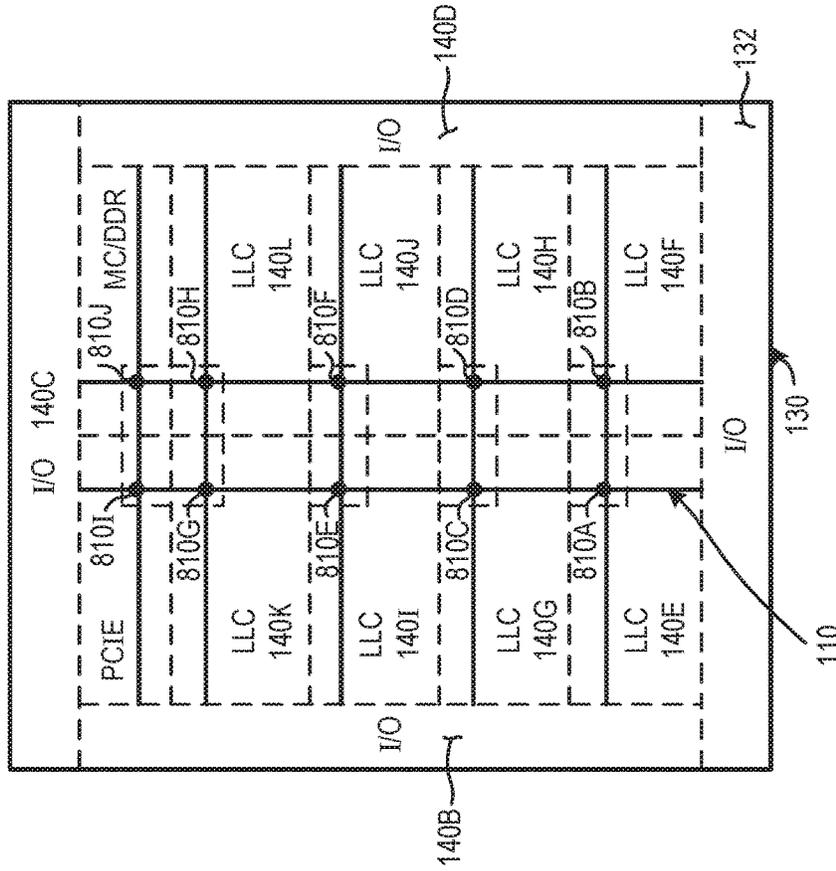
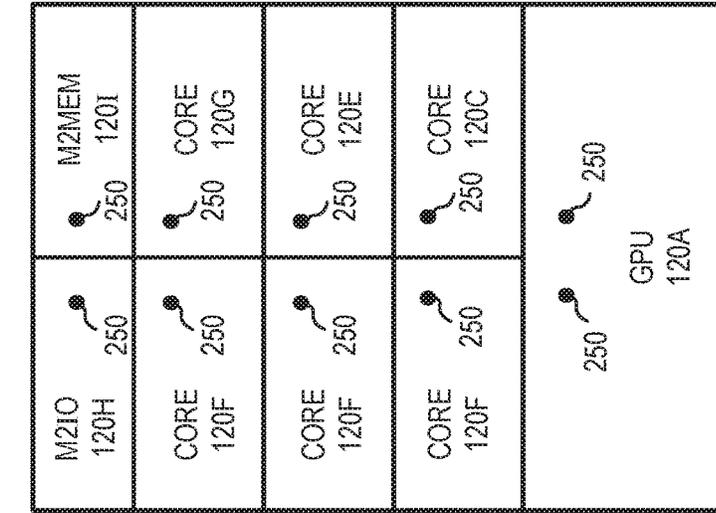


FIG. 8

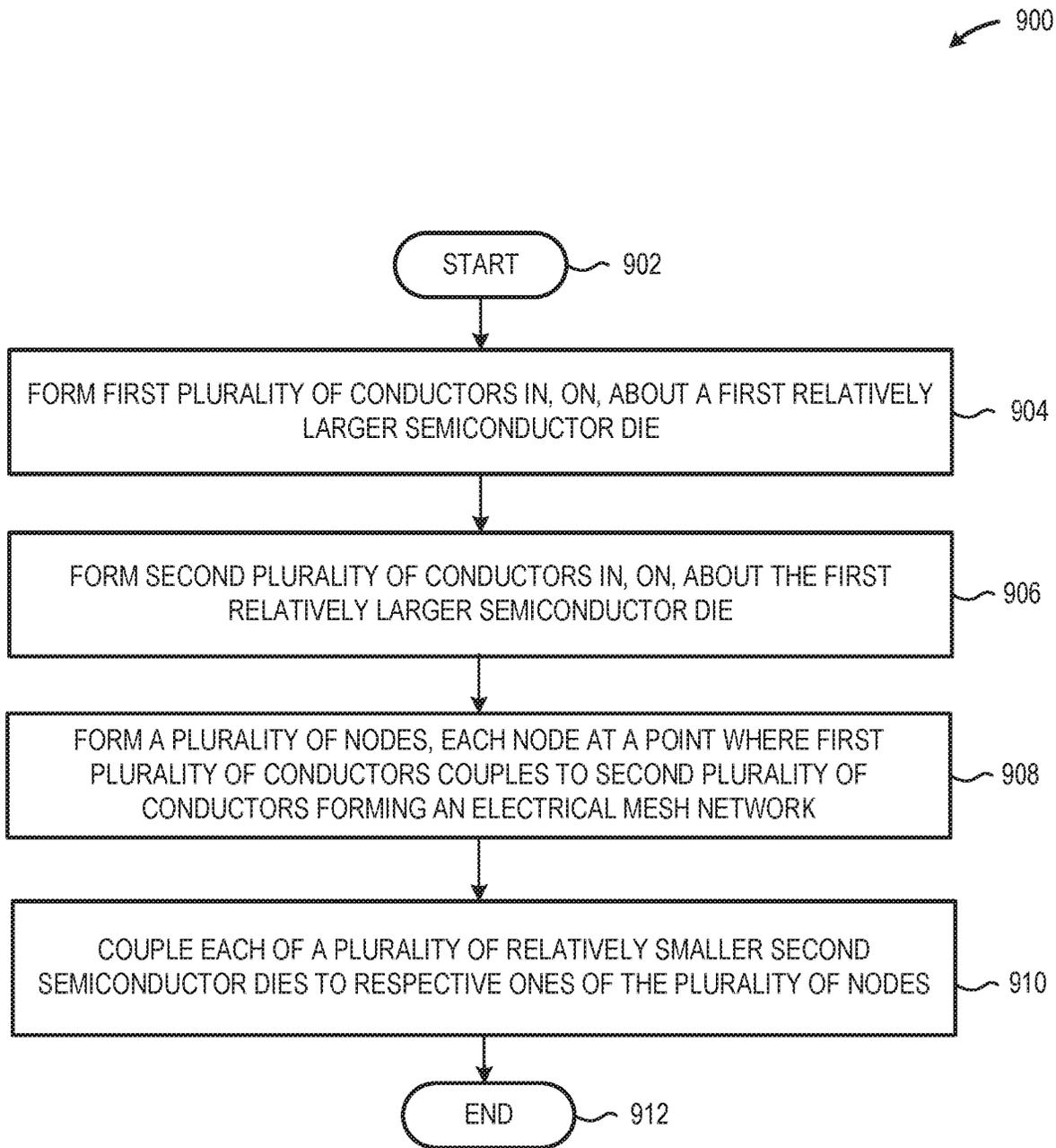


FIG. 9

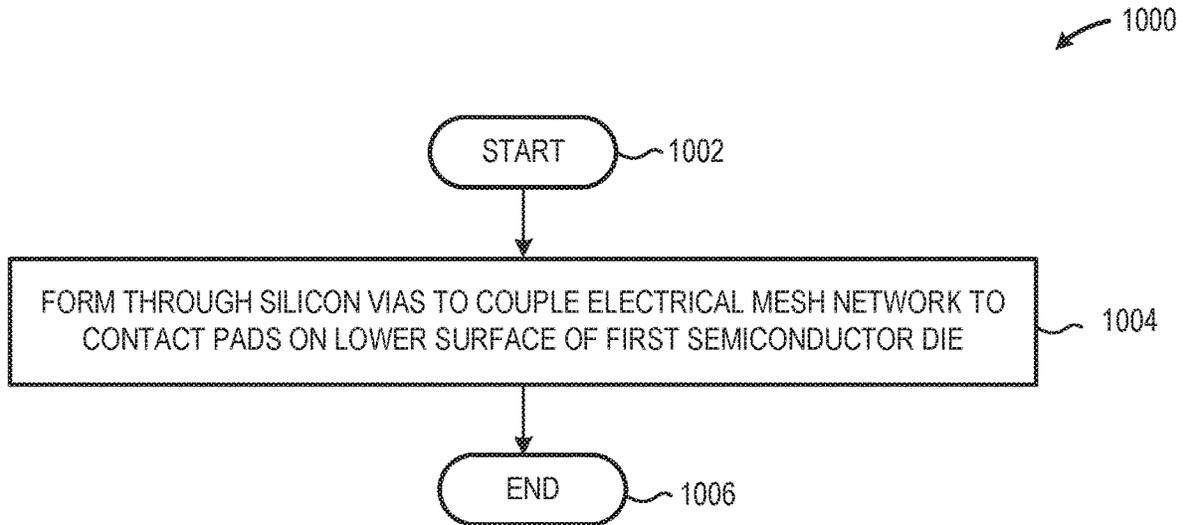


FIG. 10

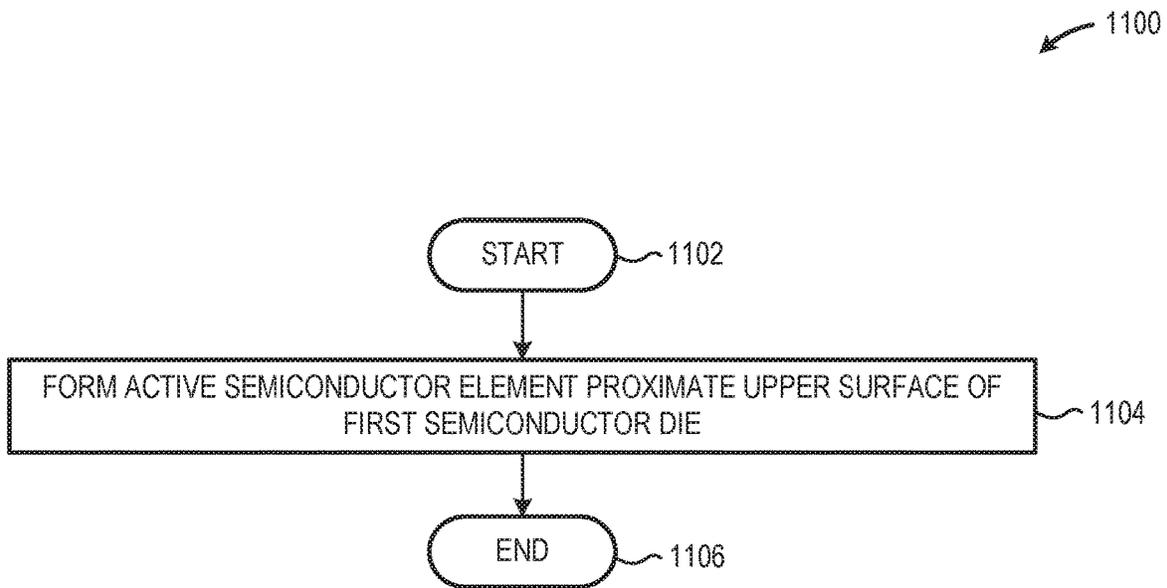


FIG. 11

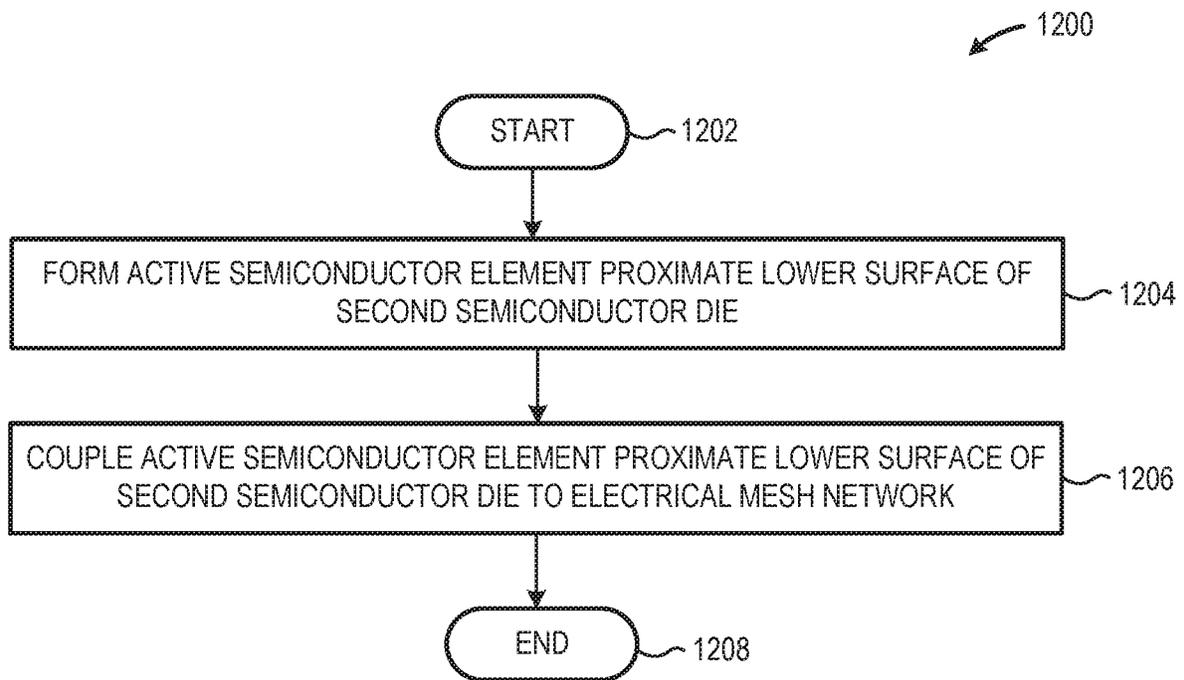


FIG. 12

## DISTRIBUTED SEMICONDUCTOR DIE AND PACKAGE ARCHITECTURE

### CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a division of U.S. patent application Ser. No. 15/869,637, filed on Jan. 12, 2018, now U.S. Pat. No. 10,685,947 issued Jun. 16, 2020, the entire contents of which is hereby incorporated by reference herein.

### TECHNICAL FIELD

The present disclosure relates to semiconductor packaging and die architecture.

### BACKGROUND

Next-generation Compute Devices, Programmable Logic (FPGA), Graphics units, (also called Compute Devices) and data centers are trending toward systems providing greater computational capabilities, operational flexibility, and improved power efficiency. The combination of demands presented by next-generation data centers and Compute devices present significant challenges for current general-purpose servers. Increasing demand for reduced system complexity, business agility and scalability has increased demand for virtualized data center infrastructure that will place additional demands on next-generation data servers. To meet such varied requirements, next-generation servers may be designed to address a specific workload matrix. However, such task- or service-oriented design, while improving power efficiency, compromises the long term flexibility of such next-generation servers. Thus, the servers used in next-generation data centers must be capable of providing a cost effective solution that addresses current and future computational demands, provide a flexible platform capable of meeting evolving operational needs, while delivering improved power efficiency over legacy servers.

The challenges presented by the growing ubiquity of Internet-of-Things (IoT) devices are surprisingly similar to those presented by next-generation data centers. With literally billions of connected devices, cloud-based infrastructure must quickly evaluate high-bandwidth data streams and determine which data may be processed and which data may be safely dropped.

Next-generation platforms share several distinct requirements: increased bandwidth; increased flexibility to promote increased functionality; improved power efficiency (or reduced power consumption) and reduced footprint requirements. Heretofore, designers may address such varied demands by packing additional components on a standard printed circuit board. The limitations inherent in such single board solutions may not satisfactorily address the multiple demands placed on next-generation devices. Such limitations include: chip-to-chip bandwidth limitations based on interconnect density; the power demand of long distance traces between chips; and the increased physical size of printed circuit boards to accommodate the chips. Monolithic integration of system components provides a potential solution, however such integration does not readily permit the integration of system components, each of which may evolve at different rates. For example, a logic chip built using a newer technology may not easily integrate or lend itself to monolithic fabrication with a memory chip built using an older technology.

Conventional solutions are therefore unable to meet future demands of higher bandwidth, greater power efficiency, increased functionality, and increased operational flexibility—all in a physically smaller package and die architecture.

### BRIEF DESCRIPTION OF THE DRAWINGS

Features and advantages of various embodiments of the claimed subject matter will become apparent as the following Detailed Description proceeds, and upon reference to the Drawings, wherein like numerals designate like parts, and in which:

FIG. 1 is a schematic of an illustrative semiconductor package and die architecture that includes an electrical mesh network conductively coupled to each of a plurality of semiconductor intellectual property cores (“IP cores”) and conductively coupled to a base die that includes a plurality of support circuits, in accordance with at least one embodiment described herein;

FIG. 2 is a partial cross-sectional elevation of an illustrative semiconductor package and die architecture that includes an electrical mesh network communicably coupling a plurality of IP cores to a base die, in accordance with at least one embodiment described herein;

FIG. 3A is a plan view of an illustrative semiconductor package and die architecture that includes an electrical mesh network that includes a first plurality of conductors and a second plurality of conductors disposed orthogonally to the first conductors, in accordance with at least one embodiment described herein;

FIG. 3B is a cross-sectional elevation of the illustrative semiconductor package and die architecture depicted in FIG. 3A along section line 3B-3B, in accordance with at least one embodiment described herein;

FIG. 4 is a schematic diagram of an illustrative processor-based device that includes one or more semiconductor packages and die architectures each having an electrical mesh network that conductively couples a plurality of IP cores to a base die as described in FIGS. 1-3, in accordance with at least one embodiment described herein;

FIG. 5 is a plan view of an illustrative semiconductor package and die architecture that includes an electrical mesh network in a “ring” configuration in which the first plurality of conductors is arranged such that the individual conductors are positioned end-to-end to form a closed loop, in accordance with at least one embodiment described herein;

FIG. 6 is a plan view of an illustrative semiconductor package and die architecture that includes an electrical mesh network in a “toroidal” network configuration in which each of conductors included in the first plurality of conductors and each of the conductors included in the second plurality of conductors “loop” between a portion of the IP cores, in accordance with at least one embodiment described herein;

FIG. 7 is a plan view of an illustrative semiconductor package and die architecture that includes an electrical mesh network in a “star” network configuration in which each of conductors included in the first plurality of conductors conductively couple each of the peripheral IP cores to a central IP core, in accordance with at least one embodiment described herein;

FIG. 8 is a plan view of a base die and an arrangement of IP cores to conductively couple to respective ones of each of a plurality of nodes included in the electrical mesh network disposed on the upper surface of the base die, in accordance with at least one embodiment described herein;

FIG. 9 is a high-level logic flow diagram depicting an illustrative method for conductively coupling a plurality of

IP cores to a base die using an electrical mesh network disposed proximate an upper surface of the base die, in accordance with at least one embodiment described herein;

FIG. 10 is a high-level flow diagram of an illustrative method of coupling an electrical mesh network disposed on at least a portion of an upper surface of the base die to one or more conductive structures on the lower surface of the base die, in accordance with at least one embodiment described herein;

FIG. 11 is a high-level flow diagram of an illustrative method of forming one or more active components and/or support circuitry that includes one or more active components in a region or portion of the base die proximate the upper surface of the base die, in accordance with at least one embodiment described herein; and

FIG. 12 is a high-level flow diagram of an illustrative method of forming one or more active components and/or circuitry that includes one or more active components in a region or portion of the IP core proximate the lower surface of the IP core, in accordance with at least one embodiment described herein.

Although the following Detailed Description will proceed with reference being made to illustrative embodiments, many alternatives, modifications and variations thereof will be apparent to those skilled in the art.

#### DETAILED DESCRIPTION

The systems and methods described herein include an electrical mesh network that couples a plurality of semiconductor intellectual property cores (hereinafter, “IP core” or collectively, “IP cores”) to a single base die that includes circuitry to support the collective operation of the IP cores (“support circuitry”). For example, the base die may include data storage circuitry, voltage regulation circuitry, and/or input/output (I/O) circuitry conductively coupled, via the electrical mesh network, to a plurality of IP cores disposed across the upper surface of the base die. Such an arrangement beneficially and advantageously permits the selection of IP cores or a mixture of IP cores that address a particular need or functionality while still retaining a “standard” or “generic” base die configuration. Example IP cores may include, but are not limited to, semiconductor dies having: processor core circuitry, graphics processing circuitry, field programmable gate array circuitry, neural network circuitry, quantum computing circuitry, and similar.

The use of an electrical mesh network to conductively couple the IP cores to the base die beneficially reduces the physical separation between components, thereby improving bandwidth while reducing transmission power losses. Further, such an architecture provides flexibility to accommodate relatively rapid evolution in IP core technology by simply attaching the newly developed IP cores to a base die that may evolve at a much slower rate. Thus, evolutionary changes in IP core technology are readily combined with the base die, without requiring a full semiconductor package redesign as would be needed if the IP core circuitry and the support circuitry found on the base die were formed monolithically. For example, patterning an orthogonal electrical mesh network on an upper surface of the base die may form a plurality of “nodes” where the individual conductors forming the electrical mesh network intersect—IP cores may be conductively coupled to each of some or all of the nodes included in the plurality of nodes. In addition, they failure rate for semiconductor dies increases with the number of components, circuits, and systems incorporated in the die (i.e., failure rate typically increases with the size and/or

complexity of the semiconductor die). Reducing the component count on the IP cores beneficially reduces both: the physical size of the die and the failure rate.

Where traditional solutions positioned dies on a two-dimensional circuit board, the systems and methods described herein stack the dies in a three-dimensional space, reducing the footprint, improving communication speed, and reducing power consumption. More specifically, the systems and methods disclosed herein dispose each IP core circuit on a relatively small semiconductor die. The plurality of IP core dies may be physically, conductively and communicably coupled to a relatively large base die that provides the collective support circuitry used by the plurality of conductively coupled IP core circuits. Example support circuitry may include, but is not limited to, voltage regulation circuitry, input/output circuitry, data storage circuitry, etc.

A semiconductor package and die architecture is provided. The semiconductor package and die or multiple dies may include: a base die having an upper surface and a lower surface, the base die including input/output circuitry; an electrical mesh network disposed proximate the upper surface of the base die and conductively coupled to the input/output circuitry included in the base die, the electrical mesh network including: a first plurality of conductors wherein; each of the first plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining first plurality of conductors; and a second plurality of conductors, wherein: each of the second plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining second plurality of conductors; and each of the second plurality of conductors intersects and conductively couples to at least one of the first plurality of conductors; a plurality of IP cores, each of the plurality of IP cores including processor core circuitry, each of the IP cores conductively coupled to a node formed by an intersection of one of the first plurality of conductors with one of the second plurality of conductors.

A semiconductor die and packaging method is provided. The method may include: forming a first plurality of conductors proximate an upper surface of a base die; forming a second plurality of conductors proximate the upper surface of the base die, wherein: each of the first plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining first plurality of conductors; each of the second plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining second plurality of conductors; and each of the first plurality of conductors intersects and conductively couples to at least one of the second plurality of conductors to form an electrical mesh network, the electrical mesh network conductively coupled to circuitry included in the base die; and conductively coupling each of a plurality of IP cores to a respective node formed by an intersection of one of the first plurality of conductors with one of the second plurality of conductors.

An electronic device is provided. The electronic device may include: a printed circuit board; and a semiconductor package conductively coupled to the printed circuit board, the semiconductor package including: a base die having an upper surface and a lower surface, the base die including input/output circuitry; an electrical mesh network disposed proximate the upper surface of the base die and conductively coupled to the circuitry included in the base die, the electrical mesh network including: a first plurality of conductors wherein; each of the first plurality of conductors disposed proximate the upper surface of the base die and spaced apart

from the remaining first plurality of conductors; and a second plurality of conductors, wherein: each of the second plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining second plurality of conductors; and each of the second plurality of conductors intersects and conductively couples to at least one of the first plurality of conductors; a plurality of IP cores, each of the plurality of IP cores including processor core circuitry, each of the IP cores conductively coupled to a node formed by an intersection of one of the first plurality of conductors with one of the second plurality of conductors.

A semiconductor package system is provided. The semiconductor package system may include: means for forming a first plurality of conductors proximate an upper surface of a base die; means for forming a second plurality of conductors proximate the upper surface of the base die, where: each of the first plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining first plurality of conductors; each of the second plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining second plurality of conductors; and each of the first plurality of conductors intersects and conductively couples to at least one of the second plurality of conductors to form an electrical mesh network, the electrical mesh network conductively coupled to at least the I/O circuitry included in the base die; means for conductively coupling each of a plurality of IP cores to a node formed by an intersection of one of the first plurality of conductors with one of the second plurality of conductors.

A semiconductor package and die architecture is provided. The semiconductor package and die architecture may include: an electrical mesh network that includes: a first plurality of conductors; a second plurality of conductors, each of the second plurality of conductor intersecting at least one of the first plurality of conductors, forming a plurality of network nodes, each of the network nodes at an intersection of one of the first plurality of conductors with one of the second plurality of conductors; a base die including I/O circuitry conductively coupled to at least one of the plurality of nodes; and a plurality of IP cores, each of the plurality of IP cores including processor core circuitry; each of the plurality of IP cores conductively coupled to a respective one of the plurality of nodes.

As used herein the terms “top,” “bottom,” “upper,” “lower,” “lowermost,” and “uppermost” when used in relationship to one or more elements are intended to convey a relative rather than absolute physical configuration. Thus, an element described as an “upper film layer” or a “top element” in a device may instead form the “lowermost element” or “bottom element” in the device when the device is inverted. Similarly, an element described as the “lowermost element” or “bottom element” in the device may instead form the “uppermost element” or “top element” in the device when the device is inverted.

As used herein, the term “logically associated” when used in reference to a number of objects, systems, or elements, is intended to convey the existence of a relationship between the objects, systems, or elements such that access to one object, system, or element exposes the remaining objects, systems, or elements having a “logical association” with or to the accessed object, system, or element. An example “logical association” exists between relational databases where access to an element in a first database may provide information and/or data from one or more elements in a number of additional databases, each having an identified relationship to the accessed element. In another example, if

“A” is logically associated with “B,” accessing “A” will expose or otherwise draw information and/or data from “B,” and vice-versa.

FIG. 1 is a schematic of an illustrative semiconductor package **100** that includes an electrical mesh network **110** conductively coupled **160** to each of a plurality of semiconductor intellectual property cores **120A-120n** (singly, “IP core **120**” collectively, “IP cores **120**”) and conductively coupled **170** to a base die **130** that includes a plurality of support circuits **140A-140n** (collectively, “support circuitry **140**”), in accordance with at least one embodiment described herein. The base die **130** may communicably couple **180** to a substrate **150**, such as a multi-layer printed circuit board or similar. In embodiments, the electrical mesh network **110** includes a number of interconnected conductive pathways or members that couple each of the IP cores **120** to one or more neighboring IP cores **120**, facilitating communication between the IP cores **120**. In embodiments the interconnected conductive pathways or members forming the electrical mesh network **110** also conductively couple each of the IP cores **120** to the base die **130** facilitating communication between the IP cores **120** and the support circuitry **140**. The base die **130** provides a “resource pool” shared by some or all of the IP cores **120**. Beneficially, as new IP core technology is introduced, IP cores **120** may be substituted in the manufacturing process without requiring a redesign of the base die **130**—reducing manufacturing costs and improving manufacturing flexibility and market responsiveness.

The electrical mesh network **110** includes a first plurality of conductors and a second plurality of conductors disposed at an angle to the first plurality of conductors such that at least one of the second plurality of conductors intersects at least one of the first plurality of conductors. In some embodiments, the electrical mesh network **110** may include a first plurality of conductors disposed parallel to each other across all or a portion of the upper surface **132** of the base die **130** and a second plurality of conductors disposed parallel to each other and orthogonal to each of the first plurality of conductors. Each intersection point where one of the second plurality of conductors contacts one of the first plurality of conductors defines one of a plurality of nodes on the electrical mesh network **110**. In embodiments, each of the IP cores **120** may be conductively coupled to a respective electrical mesh network node. In embodiments, the electrical mesh network **110** may be deposited, patterned, formed, or otherwise disposed on, across, or about at least a portion of the upper surface **132** of the base die **130** using any currently available or future developed material deposition process or method. In some implementations, the electrical mesh network **110** may be formed on a single layer across all or a portion of the base die **130**—i.e., the first plurality of conductors and the second plurality of conductors may be formed on the same layer (e.g., the same metal layer) of the base die **130**. In some implementations, the electrical mesh network **110** may be formed in multiple layers across all or a portion of the base die **130**—i.e., each of the first plurality of conductors and/or each of the second plurality of conductors may be formed on two or more different layers (e.g., adjacent or non-adjacent metal layers) of the base die **130**.

Each of the semiconductor intellectual property cores (“IP cores”) **120** may include, but is not limited to, a reusable unit of logic, cell, or integrated circuit/chip/chiplet layout design. Example IP cores **120** include, but are not limited to, universal asynchronous receiver/transmitter (UARTs); central processing units (CPUs); graphics processing units (GPUs); IEEE 802.11 Ethernet controllers; Peripheral Com-

ponent Interconnect (PCI) interfaces; storage devices; and similar. Each of the IP cores **120** includes circuitry (e.g., processor core circuitry) disposed on a relatively small (compared to the base die **130**) integrated circuit. Each of the IP cores **120** has a lower surface **124** that is disposed proximate the electrical mesh network **110**. In embodiments, the machine executable instruction sets that cause the operation of the support circuitry **140** in the base die **130** may be executed in whole or in part by processor circuitry and/or controller circuitry disposed in, on, or about the IP cores **120**. In embodiments, each of the IP cores **120** may occupy the same area on the upper surface **132** of the base die **130**. In embodiments, the IP cores **120** may occupy different areas on the upper surface **132** of the base die **130**. In embodiments, the IP cores **120** may have a surface area of less than: about 25 square millimeters (mm<sup>2</sup>); about 20 mm<sup>2</sup>; about 15 mm<sup>2</sup>; about 12 mm<sup>2</sup>; about 10 mm<sup>2</sup>; about 8 mm<sup>2</sup>; or about 5 mm<sup>2</sup>.

Each of the IP cores **120** includes one or more conductive fixtures **126A-126n** (contact bumps, pads, lands, grooves, pins, etc.—collectively “conductive fixtures **126**”) disposed in, on, about, or across at least a portion of the lower surface **124** of the IP core **120**. The one or more conductive fixtures **126** may be disposed in a fixed pattern or arrangement in, on, about or across the lower surface **124** of each of the IP cores **120** conductively coupled to the base die **130**. Maintaining the conductive features **126** in a fixed pattern or arrangement beneficially permits the replacement and/or substitution of IP cores **120** without requiring a redesign of the base die **130**. For example, a newer IP core **120<sub>NEW</sub>** may selectively replace an older IP core **120<sub>OLD</sub>** in a particular semiconductor package design. Such replacement is greatly facilitated and redesign time and costs reduced or even eliminated when the arrangement of the conductive features **126** on the older IP core **120<sub>OLD</sub>** match the arrangement of the conductive features found on the newer IP core **120<sub>NEW</sub>**. Since IP cores **120** may be readily substituted without requiring a complete rework of the base die **130**, time-to-market is advantageously reduced and market responsiveness beneficially improved.

At least one of the one or more conductive fixtures **126** may conductively couple **160** the respective IP core **120** to the electrical mesh network **110**. In embodiments, at least one of the one or more conductive fixtures **126** may conductively couple **160** the IP core **120** to support circuitry **140** disposed in the base die **130**. In embodiments, an electrically conductive micro solder bumps, solder balls, solder paste, or similar material may physically and/or electrically conductively couple **160** the IP cores **120** to the electrical mesh network **110** and/or support circuitry in the base die **130**.

The base die **130** includes support circuitry **140** that is deposited, patterned, formed, or otherwise disposed in, on, or about the base die **130**. In embodiments, the support circuitry **140** may include, but is not limited to, one or more of the following: data storage circuitry; cache circuitry; input/output circuitry; processor voltage regulation circuitry (e.g., fully integrated voltage regulator or “FIVR” circuitry); communications interface circuitry; bus interface circuitry; and combinations thereof. The base die **130** may provide the substrate for the semiconductor package **100**. In embodiments, the base die **130** is relatively larger than each of the IP cores **120**. In embodiments, the base die may have an upper surface area of less than: about 3000 square millimeters (mm<sup>2</sup>); about 2500 mm<sup>2</sup>; about 2000 mm<sup>2</sup>; about 1500 mm<sup>2</sup>; about 1000 mm<sup>2</sup>; about 700 mm<sup>2</sup>; or about 500 mm<sup>2</sup>. In embodiments, all or a portion of the peripheral regions of the base die **130** may include I/O circuitry. In embodiments,

all or a portion of the central region of the base die **130** bounded by the peripheral regions may include cache memory circuitry. In such embodiments, the IP cores **120** may be coupled to the electrical mesh network **110** and/or base die **130** in the central region of the base die **130** that include the cache memory circuitry. Disposing the IP cores **120** proximate the cache memory circuitry in the base die beneficially reduces cache access time, thereby improving the performance of the semiconductor package **100**.

At least a portion of the electrical mesh network **110** may be disposed, patterned, deposited, or otherwise formed in, on, about, or across at least a portion of the upper surface **132** of the base die **130**. In embodiments, the electrical mesh network **110** may be formed as a single metal layer on the upper surface **132** of the base die **130**. In other embodiments, the electrical mesh network **110** may be formed as a plurality of metal layers on the upper surface **132** of the base die **130**. The electrical mesh network **110** may be formed using any currently available or future developed material deposition and/or patterning process or method. Non-limiting examples of material deposition and/or patterning processes include, but are not limited to, photolithography, printing, electroplating, electro-less plating, chemical vapor deposition, atomic layer deposition, physical layer deposition, and similar. The support circuitry **140** disposed in the base die **130** communicably couples **170** to the electrical mesh network **110** using conductors such as metal traces, vias, and similar that are disposed in, on, or about the base die **130**.

In addition to conductively coupling to the electrical mesh network **110**, at least some of the IP cores **120** may conductively couple to the support circuitry **140** disposed in the base die **130**. In embodiments, one or more conductive structures **136** may be deposited, patterned, formed, or otherwise disposed in, on, about, or across all or a portion of the upper surface **132** of the base die **130** to couple at least one IP core **120** to the support circuitry **140** carried by the base die **130**. Conductors, such as metal traces, vias, etc., couple the conductive structures **136** on the upper surface **132** of the base die **130** to the support circuitry **140**.

A plurality of conductive features **138** may be deposited, patterned, formed, or otherwise disposed in, on, about, or across at least a portion of the lower surface **134** of the base die **130**. The plurality of conductive features **138** conductively couple **180** the base die **130** (and the semiconductor package **100**) to a substrate **150**, such as a printed circuit board, motherboard, daughterboard, server blade, or similar. Conductors, such as metal traces, vias, etc., conductively couple the conductive features **138** on the lower surface **132** of the base die **130** to the support circuitry **140** and/or the electrical mesh network **110**.

FIG. 2 is a partial cross-sectional elevation of an illustrative semiconductor package **200** that includes an electrical mesh network **110** communicably coupling a plurality of IP cores **120A-120C** to a base die **130**, in accordance with at least one embodiment described herein. As depicted in FIG. 2, semiconductor components, including active semiconductor components such as transistors, may be formed or otherwise disposed in a lower portion **210** of each of the respective IP cores **120**. Disposing semiconductor components in the lower portion **210** of each of the IP cores **120** reduces the physical separation between the circuitry containing the respective semiconductor components and the electrical mesh network **110**, beneficially improving performance while reducing power losses. Similarly, semiconductor components, including active semiconductor components such as transistors, may be formed or otherwise disposed in an upper portion **220** of the base die **130**. In at

least some embodiments, at least some of the semiconductor components disposed in the upper portion 220 of the base die 130 may form all or a portion of the support circuitry 140. In such embodiments, disposing semiconductor components in the upper portion 220 of the base die 130 reduces the physical separation between the support circuitry 140 and the electrical mesh network 110, further improving performance while reducing power losses.

One or more conductors 230, such as one or more vias or traces, may conductively couple at least a portion of the semiconductor components formed or disposed in the upper portion 220 of the base die 130 to one or more of the plurality of conductive features 138 (pads, lands, contacts, grooves, pins, etc.) deposited, formed, patterned, or otherwise disposed in, on, about, or across the lower surface of the base die 130. Conductive structures 240A-240n, such as solder bumps, solder balls, clips, and/or pins, may be used to physically and conductively couple the base die 130 to the substrate 150.

One or more conductive structures 250A-250n (collectively, “conductive structures 250”), such as one or more micro-bumps, solder bumps, solder balls, or similar conductively couple each of the IP cores 120 to the electrical mesh network 110 and/or the base die 130. In embodiments, the one or more conductive structures may include a plurality of micro-bumps arranged on a fine pitch array. For example, the conductive structures 250 may include micro-bumps formed from copper (Cu), copper containing alloys, silver (Ag), silver containing alloys, nickel (Ni), nickel containing alloys, and combinations thereof. In embodiments, the conductive structures 250 may include micro-bumps having a diameter of less than: about 50 micrometers ( $\mu\text{m}$ ); about 40  $\mu\text{m}$ ; about 30  $\mu\text{m}$ ; about 25  $\mu\text{m}$ ; about 15  $\mu\text{m}$ ; or about 10  $\mu\text{m}$ . In embodiments, the conductive structures 250 may be disposed on a pitch of less than: about 70 micrometers ( $\mu\text{m}$ ); about 60  $\mu\text{m}$ ; about 50  $\mu\text{m}$ ; about 40  $\mu\text{m}$ ; about 30  $\mu\text{m}$ , or about 20  $\mu\text{m}$ . In some implementations, a fine layer of solder similar electrically conductive material capable of reflow may be disposed proximate the conductive fixtures 126 disposed on the lower surface 124 of the IP cores 120.

FIG. 3A is a plan view of an illustrative semiconductor package 300 that includes an electrical mesh network 110 that includes a first plurality of conductors 310A-310n (collectively “first conductors 310”) and a second plurality of conductors 320A-320n (collectively, “second conductors 320”) disposed orthogonally to the first conductors 310, in accordance with at least one embodiment described herein. FIG. 3B is a cross-sectional elevation of the illustrative semiconductor package depicted in FIG. 3A along section line 3B-3B, in accordance with at least one embodiment described herein. As depicted in FIGS. 3A and 3B, the electrical mesh network 110 conductively and physically couples a plurality of IP cores 120A-120n to a base die 130 that includes a plurality of support circuitry 140A-140n.

Each of the IP cores 120 may include any number of circuits or circuitry. As depicted in FIG. 3A, each of the IP cores 120A-120n include four processor core circuits 330A-330D (collectively, “processor core circuits 330”). Each of the processor core circuits 330 is conductively coupled to the electrical mesh network 110. The electrical mesh network 110 conductively couples each of the IP cores 120 to at least a portion of the remaining IP cores. The electrical mesh network 110 also conductively couples each of the IP cores 120 to the support circuitry 140 disposed in the base die 130.

The base die 130 includes a plurality of support circuits 140. In embodiments, the base die 130 may include a region

containing cache storage circuits 330. In such embodiments, the IP cores 120 may be positioned proximate the region of the base die 130 that includes the cache storage circuits 330. Positioning the IP cores 120 proximate the cache storage circuits beneficially improves cache access times while reducing power consumption.

A number of support circuits 140, including input/output (I/O) circuits may be deposited, formed, patterned, or otherwise disposed in, on, across, or about the periphery of the base die 130. The I/O circuits may include any currently available or future developed I/O circuits 140. Example I/O circuits may include, but are not limited to, serial I/O interfaces, parallel I/O interfaces; wired I/O interfaces; wireless I/O interfaces; or combinations thereof. In the example semiconductor package 300 depicted in FIGS. 3A and 3B, the I/O circuits include general purpose I/O (GPIO) circuitry 140C; ultra-path interconnect (UPI) circuitry 140D, 140R; peripheral component interconnect (PCI) circuitry 140E, 140F, 140L, 140M, 140N, 140O; and RLink circuitry 140G, 140H, 140P, 140Q.

An additional number of support circuits 140, including data storage circuits may be deposited, formed, patterned, or otherwise disposed in, on, across, or about the periphery of the base die 130. The data storage circuits may include any currently available or future developed data storage technology. Such data storage circuits may include, but are not limited to, electrostatic data storage circuits; quantum data storage circuits; molecular data storage circuits; electroresistive data storage circuits; optical data storage circuits; or combinations thereof. In the example semiconductor package 300 depicted in FIGS. 3A and 3B, the base die 130 includes dual data rate (DDR) I/O circuitry 140A, 140B, 140J, and 140K.

The first plurality of conductors 310 includes conductors 310A-310n deposited, formed, patterned, or otherwise disposed in, on, about, or across the upper surface 132 of the base die 130. In embodiments, the conductors 310A-310n included in the first plurality of conductors 310 may be disposed on the same or different metal layers disposed in, on, or about the base die 130. In embodiments, each of the conductors 310A-310n included in the first plurality of conductors 310 may be deposited, formed, patterned, or otherwise disposed in a regular or irregular pattern on the upper surface 132 of the base die 130. Although depicted in FIG. 3A as deposited in a straight line, each of the conductors 310A-310n included in the plurality of conductors 310 may have any configuration that includes, but is not limited to, having: any shape, any dimensions (length, height, width, etc.), and/or or any physical configuration (curved, sinusoidal, elliptical, circular, polygonal, etc.).

In embodiments, the spacing or physical distance between each of the conductors 310A-310n included in the first plurality of conductors 310 may be the same or different. In embodiments, the spacing between any two of the conductors 310A-310n included in the first plurality of conductors 310 may be constant or variable. In embodiments, the conductors 310A-310n included in the first plurality of conductors 310 may be disposed parallel to each other and with a constant or variable separation distance between adjacent conductors. The conductors 310A-310n included in the first plurality of conductors 310 may be composed of a metallic or non-metallic, electrically conductive, material. Example metallic materials include, but are not limited to, copper, copper containing alloys, aluminum, aluminum containing alloys, and similar. Example non-metallic materials include conductive polymers and conductive nanoparticles (e.g., silver nanowires) suspended in a polymer matrix.

The second plurality of conductors **320** includes conductors **320A-320n** deposited, formed, patterned, or otherwise disposed in, on, about, or across the upper surface **132** of the base die **130**. In embodiments, the conductors **320A-320n** included in the second plurality of conductors **320** may be disposed on the same or different layers included in the base die **130**. In embodiments, some or all of the conductors **320A-320n** included in the second plurality of conductors **320** may be disposed on the same or different layers than some or all of the conductors **310A-310n** included in the first plurality of conductors **310**. Although depicted in FIG. 3A as deposited in a straight line, each of the conductors **320A-320n** included in the second plurality of conductors **320** may have any configuration that includes, but is not limited to, having: any shape, any dimensions (length, height, width, etc.), and/or any physical configuration (curved, sinusoidal, elliptical, circular, polygonal, etc.).

In embodiments, at least one of the conductors **320A-320n** included in the second plurality of conductors **320** intersects at least one of the conductors **310A-310n** included in the first plurality of conductors **310** to form the electrical mesh network **110**. In other embodiments, at least one of the conductors **320A-320n** included in the second plurality of conductors **320** intersects each of the conductors **310A-310n** included in the first plurality of conductors **310** to form the electrical mesh network **110**. In yet other embodiments, each of the conductors **320A-320n** included in the second plurality of conductors **320** intersects each of the conductors **310A-310n** included in the first plurality of conductors **310** to form the electrical mesh network **110**.

Each of the conductors **320A-320n** included in the second plurality of conductors **320** may be disposed at any angle measured with respect to the conductors **310A-310n** included in the first plurality of conductors **310**. In embodiments, at least one of the conductors **320A-320n** included in the second plurality of conductors **320** may be disposed orthogonal to at least one of the conductors **310A-310n** included in the first plurality of conductors **310**. In embodiments, each of the conductors **320A-320n** included in the second plurality of conductors **320** may be disposed orthogonal to each of the conductors **310A-310n** included in the first plurality of conductors **310**.

The electrical mesh network **110** formed by the conductors **310A-310n** included in the first plurality of conductors **310** and the conductors **320A-320n** included in the second plurality of conductors **320** form an electrical mesh network **110** that includes plurality of nodes. The intersection and/or electrical coupling of a conductive member **310** with a conductive member **320** forms a "node" on the electrical mesh network **110**. Where the conductor **310** and the conductor **320** are formed or disposed on the same layer in the base die **130**, the node is the location where the conductors **310** and **320** intersect. Where conductor **310** and conductor **320** are formed disposed on different layers in the base die **130**, the node occurs at the location where a via or similar conductive feature electrically couples conductor **310** with conductor **320**.

In embodiments, each of the conductors **320A-320n** included in the second plurality of conductors **320** may be deposited, formed, patterned, or otherwise disposed in a regular or irregular pattern on the upper surface **132** of the base die **130**. In embodiments, the spacing between each of the conductors **320A-320n** included in the second plurality of conductors **320** may be the same or different. In embodiments, the spacing between any two of the conductors **320A-320n** included in the second plurality of conductors **320** may be constant or variable. In embodiments, the

conductors **320A-320n** included in the second plurality of conductors **320** may be disposed parallel to each other and with a constant or variable separation distance between adjacent conductors. The conductors **320A-320n** included in the second plurality of conductors **320** may be composed of a metallic or non-metallic, electrically conductive, material. Example metallic materials include, but are not limited to, copper, copper containing alloys, aluminum, aluminum containing alloys, and similar. Example non-metallic materials include conductive polymers and conductive nanoparticles (e.g., silver nanowires) suspended in a polymer matrix.

The conductors **310A-310n** included in the first plurality of conductors **310** and the conductors **320A-320n** included in the second plurality of conductors **320** may be formed, patterned, deposited, and/or disposed in, on, across, or about the base die **130** using any currently available or future developed material deposition processes and/or methods. Example, non-limiting, material deposition processes include, but are not limited to: photolithography, printing, electroplating, electroless plating, thin film deposition, atomic layer deposition, and similar. In embodiments, all or a portion of the conductors **310A-310n** included in the first plurality of conductors **310** and/or all or a portion of the conductors **320A-320n** included in the second plurality of conductors **320** may be disposed at any layer and/or location across the thickness of the base die **130** such that all or a portion of the electrical mesh network **110** is formed internal to the base die **130**. In other embodiments, all or a portion of the conductors **310A-310n** included in the first plurality of conductors **310** and/or all or a portion of the conductors **320A-320n** included in the second plurality of conductors **320** may be disposed in, on, about, or across at least a portion of the lower surface **134** of the base die **130** such that all or a portion of the electrical mesh network **110** is formed on at least a portion of the lower surface **134**. In such embodiments one or more through silicon vias (TSVs) may conductively couple one or more IP cores **120** to the electrical mesh network **110**. In yet other embodiments, all or a portion of the conductors **310A-310n** included in the first plurality of conductors **310** and/or all or a portion of the conductors **320A-320n** included in the second plurality of conductors **320** may be disposed in, on, about, or across at least a portion of the upper surface **132** of the base die **130** such that all or a portion of the electrical mesh network **110** is formed on at least a portion of the upper surface **132**.

FIG. 4 is a schematic diagram of an illustrative processor-based device **400** that includes one or more semiconductor packages **100A**, **100B**, each having an electrical mesh network **110** that conductively couples a plurality of IP cores **120** to a base die **130** as described in FIGS. 1-3, in accordance with at least one embodiment described herein. The processor-based device **400** may include one or more: processor circuits **410**, graphics processor circuits **412**, wireless input/output (I/O) interfaces **420**, wired I/O interfaces **430**, memory circuits **440**, power management circuits **450**, storage devices **460**, and/or network interfaces **470**. The following discussion provides a brief, general description of the components forming the illustrative processor-based device **400**. Example, non-limiting processor-based devices **400** may include: smartphones, wearable computers, portable computing devices, handheld computing devices, desktop computing devices, blade server devices, workstations, and similar.

The processor-based device **400** includes processor circuitry **410** having an electrical mesh network **110** that conductively couples a plurality of IP cores **120** to a base die **130**. In embodiments, the processor-based device **400** may

additionally include graphics processor circuitry **412** having an electrical mesh network **110** that conductively couples a plurality of IP cores **120** to a base die **130**. In embodiments, the processor-based device **400** includes one or more processor circuits **410** capable of executing machine-readable instruction sets **414**, reading data and/or instructions **414** from one or more storage devices **460** and writing data to the one or more storage devices **460**. In some embodiments, the processor-based device **400** includes one or more graphics processor circuits **412** capable of executing machine-readable instruction sets **414** and generating an output signal capable of providing a display output to a system user. Those skilled in the relevant art will appreciate that the illustrated embodiments as well as other embodiments may be practiced with other processor-based device configurations, including portable electronic or handheld electronic devices, for instance smartphones, portable computers, wearable computers, consumer electronics, personal computers (“PCs”), network PCs, minicomputers, server blades, mainframe computers, and the like.

The processor circuitry **410** may include any number of hardwired or configurable circuits, some or all of which may include programmable and/or configurable combinations of electronic components, semiconductor devices, and/or logic elements that are disposed partially or wholly in a PC, server, or other computing system capable of executing processor-readable instructions.

The processor-based device **400** includes a bus or similar communications link **416** that communicably couples and facilitates the exchange of information and/or data between various system components including the processor circuitry **410**, the graphics processor circuitry **412**, one or more wireless I/O interfaces **420**, one or more wired I/O interfaces **430**, one or more storage devices **460**, and/or one or more network interfaces **470**. The processor-based device **400** may be referred to in the singular herein, but this is not intended to limit the embodiments to a single processor-based device **400**, since in certain embodiments, there may be more than one processor-based device **400** that incorporates, includes, or contains any number of communicably coupled, collocated, or remote networked circuits or devices.

The processor circuitry **410** may include one or more semiconductor packages **100A** that include a electrical mesh network **110** coupled to a plurality of relatively small IP cores **120** and a single, relatively large, base die **130**. The graphics processor circuitry **412** may include one or more semiconductor packages **100B** that include a electrical mesh network **110** coupled to a plurality of relatively small IP cores **120** and a single, relatively large, base die **130**.

The processor circuitry **410** may include any number, type, or combination of devices. The processor circuitry **410** may include, but is not limited to any current or future developed single- or multi-core processor or microprocessor, such as: on or more systems on a chip (SOCs); central processing units (CPUs); digital signal processors (DSPs); graphics processing units (GPUs); application-specific integrated circuits (ASICs), programmable logic units, field programmable gate arrays (FPGAs), and the like. Unless described otherwise, the construction and operation of the various blocks shown in FIG. **4** are of conventional design. Consequently, such blocks need not be described in further detail herein, as they will be understood by those skilled in the relevant art. The bus **416** that interconnects at least some of the components of the processor-based device **400** may employ any known serial or parallel bus structures or architectures.

The system memory **440** may include read-only memory (“ROM”) **442** and random access memory (“RAM”) **446**. A portion of the ROM **442** may be used to store or otherwise retain a basic input/output system (“BIOS”) **444**. The BIOS **444** provides basic functionality to the processor-based device **400**, for example by causing the processor circuitry **410** to load one or more machine-readable instruction sets **414**. In embodiments, at least some of the one or more machine-readable instruction sets **414** cause at least a portion of the processor circuitry **410** to provide, create, produce, transition, and/or function as a dedicated, specific, and particular machine, for example a word processing machine, a digital image acquisition machine, a media playing machine, a gaming system, a communications device, or similar.

The processor-based device **400** may include at least one wireless input/output (I/O) interface **420**. The at least one wireless I/O interface **420** may be communicably coupled to one or more physical output devices **422** (tactile devices, video displays, audio output devices, hardcopy output devices, etc.). The at least one wireless I/O interface **420** may communicably couple to one or more physical input devices **424** (pointing devices, touchscreens, keyboards, tactile devices, etc.). The at least one wireless I/O interface **420** may include any currently available or future developed wireless I/O interface. Example wireless I/O interfaces include, but are not limited to: BLUETOOTH®, near field communication (NFC), and similar.

The processor-based device **400** may include one or more wired input/output (I/O) interfaces **430**. The at least one wired I/O interface **430** may be communicably coupled to one or more physical output devices **422** (tactile devices, video displays, audio output devices, hardcopy output devices, etc.). The at least one wired I/O interface **430** may be communicably coupled to one or more physical input devices **424** (pointing devices, touchscreens, keyboards, tactile devices, etc.). The wired I/O interface **430** may include any currently available or future developed I/O interface. Example wired I/O interfaces include, but are not limited to: universal serial bus (USB), IEEE 1394 (“Fire-Wire”), and similar.

The processor-based device **400** may include one or more communicably coupled, non-transitory, data storage devices **460**. The data storage devices **460** may include one or more hard disk drives (HDDs) and/or one or more solid-state storage devices (SSDs). The one or more data storage devices **460** may include any current or future developed storage appliances, network storage devices, and/or systems. Non-limiting examples of such data storage devices **460** may include, but are not limited to, any current or future developed non-transitory storage appliances or devices, such as one or more magnetic storage devices, one or more optical storage devices, one or more electro-resistive storage devices, one or more molecular storage devices, one or more quantum storage devices, or various combinations thereof. In some implementations, the one or more data storage devices **460** may include one or more removable storage devices, such as one or more flash drives, flash memories, flash storage units, or similar appliances or devices capable of communicable coupling to and decoupling from the processor-based device **400**.

The one or more data storage devices **460** may include interfaces or controllers (not shown) communicatively coupling the respective storage device or system to the bus **416**. The one or more data storage devices **460** may store, retain, or otherwise contain machine-readable instruction sets, data structures, program modules, data stores, databases, logical

structures, and/or other data useful to the processor circuitry 410 and/or graphics processor circuitry 412 and/or one or more applications executed on or by the processor circuitry 410 and/or graphics processor circuitry 412. In some instances, one or more data storage devices 460 may be communicably coupled to the processor circuitry 410, for example via the bus 416 or via one or more wired communications interfaces 430 (e.g., Universal Serial Bus or USB); one or more wireless communications interfaces 420 (e.g., Bluetooth®, Near Field Communication or NFC); and/or one or more network interfaces 470 (IEEE 802.3 or Ethernet, IEEE 802.11, or WiFi®, etc.).

Processor-readable instruction sets 414 and other programs, applications, logic sets, and/or modules may be stored in whole or in part in the system memory 440. Such instruction sets 414 may be transferred, in whole or in part, from the one or more data storage devices 460. The instruction sets 414 may be loaded, stored, or otherwise retained in system memory 440, in whole or in part, during execution by the processor circuitry 410 and/or graphics processor circuitry 412. The processor-readable instruction sets 414 may include machine-readable and/or processor-readable code, instructions, or similar logic capable of providing the speech coaching functions and capabilities described herein.

The processor-based device 400 may include power management circuitry 450 that controls one or more operational aspects of the energy storage device 452. In embodiments, the energy storage device 452 may include one or more primary (i.e., non-rechargeable) or secondary (i.e., rechargeable) batteries or similar energy storage devices. In embodiments, the energy storage device 452 may include one or more supercapacitors or ultracapacitors. In embodiments, the power management circuitry 450 may alter, adjust, or control the flow of energy from an external power source 454 to the energy storage device 452 and/or to the processor-based device 400. The power source 454 may include, but is not limited to, a solar power system, a commercial electric grid, a portable generator, an external energy storage device, or any combination thereof.

For convenience, the processor circuitry 410, the graphics processor circuitry 412, the wireless I/O interface 420, the wired I/O interface 430, the power management circuitry 450, the storage device 460, and the network interface 470 are illustrated as communicatively coupled to each other via the bus 416, thereby providing connectivity between the above-described components. In alternative embodiments, the above-described components may be communicatively coupled in a different manner than illustrated in FIG. 4. For example, one or more of the above-described components may be directly coupled to other components, or may be coupled to each other, via one or more intermediary components (not shown). In another example, one or more of the above-described components may be integrated into the processor circuitry 410 and/or the graphics processor circuitry 412. In some embodiments, all or a portion of the bus 416 may be omitted and the components are coupled directly to each other using suitable wired or wireless connections.

FIGS. 5, 6, and 7 are plan views of various illustrative, non-limiting, electrical mesh network 110 configurations. One of the benefits of the electrical mesh network 110 described herein is the capability to tailor the configuration of the electrical mesh network 110 to suit particular geometry, manufacturing, and/or operational needs. In addition to changing or altering the physical geometry of the electrical mesh network 110, the number of conductors 310A-310n, 320A-320n included in each of the plurality of conductors 310, 320 may be varied or, as will be seen, one of the

plurality of conductors may even be eliminated. The physical size, shape, and/or cross-sectional geometry of some or all of the conductors 310A-310n, 320A-320n included in the plurality of conductors 310, 320 may be the same or differ. In embodiments, the composition and/or physical geometry of conductors 310A-310n, 320A-320n included in each of the plurality of conductors 310, 320 may be altered to provide a desired conductance, resistance, capacitance, etc. Such physical, geometric, and compositional variations in the conductors 310A-310n, 320A-320n and/or conductors forming all or a portion of the electrical mesh network 110 should be considered as falling within the scope of this disclosure.

FIG. 5 is a plan view of an illustrative semiconductor package 500 that includes an electrical mesh network 110 in a “ring” configuration in which the first plurality of conductors 310 is arranged such that the individual conductors 310A-310n are positioned end-to-end to form a closed loop, in accordance with at least one embodiment described herein. In such an arrangement, the junction between two adjoining conductors 310A-310n forms a node 510A-510n of the electrical mesh network 110. As depicted in FIG. 5, the IP cores 120 may be arranged in a generally circular or elliptical pattern on the upper surface 132 of the base die 130. Each of the IP cores 120A-120n may be conductively coupled, via one or more conductive structures 250, to a respective one of the plurality of nodes 510A-510n on the electrical mesh network 110.

FIG. 6 is a plan view of an illustrative semiconductor package 600 that includes an electrical mesh network 110 in a “toroidal” network configuration in which each of conductors 310A-310n included in the first plurality of conductors 310 and each of the conductors 320A-320n included in the second plurality of conductors 320 “loop” between a portion of the IP cores 120 disposed on the upper surface 132 of the base die 130, in accordance with at least one embodiment described herein. In the toroidal network configuration depicted in FIG. 6, each IP core 120 is conductively coupled to four neighboring IP cores 120. As depicted in FIG. 6, using a toroidal electrical mesh network 110, the IP cores 120 may be arranged in a generally orthogonal pattern on the upper surface 132 of the base die 130. Each of the IP cores 120A-120n may be conductively coupled, via one or more conductive structures 250, to a respective one of the plurality of nodes 610A-610n on the electrical mesh network 110.

FIG. 7 is a plan view of an illustrative semiconductor package 700 that includes an electrical mesh network 110 in a “star” network configuration in which each of conductors 310A-310n included in the first plurality of conductors 310 conductively couple each of the peripheral IP cores 120A-120H to a central IP core 120I, in accordance with at least one embodiment described herein. The distal (with respect to the central IP core 120I) termination point of each of the conductors 310A-310n defines a respective node 710A-710n on the electrical mesh network 110. In the star network configuration depicted in FIG. 7, each IP core 120 is conductively coupled to the central IP core 120I. As depicted in FIG. 7, using a star electrical mesh network 110, the IP cores 120 may be arranged in a generally circular or elliptical pattern about the periphery of the upper surface 132 of the base die 130. Each of the IP cores 120A-120n may be conductively coupled, via one or more conductive structures 250, to a respective one of the plurality of nodes 710A-710n on the electrical mesh network 110.

FIG. 8 is a plan view of a base die 130 and an arrangement of IP cores 120A-120I to conductively couple to respective ones of each of a plurality of nodes 810A-810J included in

the electrical mesh network **110** disposed on the upper surface **132** of the base die **130**, in accordance with at least one embodiment described herein. In the example embodiment depicted in FIG. 8, the base die includes support circuitry **140A-140N**. Support circuitry **140A-140D** includes input/output circuitry. Support circuitry **140E-140L** includes low-level cache (“LLC”) circuitry. Support circuitry **140M** includes peripheral component interconnect express (“PCIe”) circuitry. Support circuitry **140N** includes dual data rate (MC/DDR) circuitry. The IP cores **120A-120I** include graphics processor circuitry **120A**, processor core circuitry **120B-120G**, memory to input/output (M2IO) circuitry, and performance monitoring counter (M2MEM) circuitry **120I**.

As depicted in FIG. 8, the conductive structures **250** on each of the IP cores **120** aligns with a respective node **810** on the electrical mesh network **110**. The area of the base die **130** occupied by the IP cores **120** is dedicated principally to last level cache memory circuitry, thus, the separation of the IP cores **120** from the support circuitry **140** carried by the base die **130** and the configuration of the electrical mesh network **110** beneficially does not increase the area occupied by the base die **130**.

FIG. 9 is a high-level logic flow diagram depicting an illustrative method **900** for conductively coupling a plurality of IP cores **120** to a base die **130** using an electrical mesh network **110** disposed proximate an upper surface **132** of the base die **130**, in accordance with at least one embodiment described herein. The method **900** may be used in conjunction with any of the methods **1000**, **1100**, and **1200** described in detail with regard to FIGS. 10, 11, and 12, respectively. Coupling the IP cores **120** to the base die **130** using an electrical mesh network **110** beneficially minimizes the physical separation between the IP cores **120** and support circuitry **140**. Minimizing the distance between the IP cores **120** and the support circuitry **140** beneficially improves performance while reducing power consumption. Reducing component count on the IP cores **120** beneficially improves productivity by reducing the likelihood of component failure. The ability to couple evolving IP core technology to a base die **130** having an interface defined by the electrical mesh network **110** improves time-to-market, responsiveness, and productivity since time is not lost redesigning the base die for each improvement in IP core technology. The method **900** commences at **902**.

At **904**, a conductors **310A-310n** included in a first plurality of conductors **310** are patterned, formed, deposited, or otherwise disposed in, on, about, or across all or a portion of a base die **130**. In embodiments, the base die **130** may include a semiconductor die that is relatively larger when compared physically to the relatively smaller dies containing the IP core circuitry. The conductors **310A-310n** may be patterned, formed, deposited, or otherwise disposed in, on, about, or across all or a portion of a base die **130** using any currently available and/or future developed material deposition process or method. For example, the conductors **310A-310n** may be formed or otherwise deposited using a photolithographic process, an electroplating process, a vapor deposition process, an atomic layer deposition process, a printing process, a three-dimensional printing process, or combinations thereof.

In embodiments, at least a portion of the first plurality of conductors may be formed on the upper surface **132** of the base die **130**. In embodiments, at least a portion of the first plurality of conductors **310** may be formed on one or more intermediate layers within the base die **130**. The conductors **310A-310n** may be formed using any conductive material

including, but not limited to, metals (copper, aluminum, etc.), metal alloys (copper containing alloys, aluminum containing alloys, etc.), conductive non-metals (polymers, conductive nanoparticle matrices, etc.) or any combination thereof. The conductors **310A-310n** may have any physical size, shape, geometry, and/or cross-sectional profile. The conductors **310A-310n** may be disposed or otherwise deposited in any uniform or non-uniform pattern including, but not limited to, straight lines, circles, arcs, polygons, or combinations thereof. The conductors **310A-310n** may be conductively coupled to support circuitry **140** formed in, on, about, or across the base die **130** using vias, metal traces, or similar electrically conductive structures. The conductors **310A-310n** may be conductively coupled to contact pads or similar electrically conductive features on the lower surface **134** of the base die **130** by one or more through silicon vias (TSVs).

At **906**, a conductors **320A-320n** included in a first plurality of conductors **320** are patterned, formed, deposited, or otherwise disposed in, on, about, or across all or a portion of a base die **130**. The conductors **320A-320n** may be patterned, formed, deposited, or otherwise disposed in, on, about, or across all or a portion of a base die **130** using any currently available and/or future developed material deposition process or method. For example, the conductors **320A-320n** may be formed or otherwise deposited using a photolithographic process, an electroplating process, a vapor deposition process, an atomic layer deposition process, a printing process, a three-dimensional printing process, or combinations thereof.

In embodiments, at least a portion of the second plurality of conductors **320** may be formed on the upper surface **132** of the base die **130**. In embodiments, at least a portion of the second plurality of conductors **320** may be formed on one or more intermediate layers within the base die **130**. In embodiments, at least a portion of the second plurality of conductors **320** may be disposed, patterned, formed, or otherwise deposited on the same layers of the base die **130** as the first plurality of conductors **310**. In embodiments, at least a portion of the second plurality of conductors **320** may be disposed, patterned, formed, or otherwise deposited on different layers of the base die **130** than the first plurality of conductors **310**. In such embodiments, vias, traces, or similar electrically conductive elements may conductively couple one or more conductors **320A-320n** to one or more conductors **310A-310n**.

In embodiments, at least one of the conductors **320A-320n** included in the second plurality of conductors **320** intersects or is conductively coupled to at least one of the conductors **310A-310n** included in the first plurality of conductors **310**. In other embodiments, each of the conductors **320A-320n** included in the second plurality of conductors **320** intersects or is conductively coupled to each of the conductors **310A-310n** included in the first plurality of conductors **310**. The conductors **320A-320n** included in the second plurality of conductors **320** may intersect the conductors **310A-310n** included in the first plurality of conductors **310** at any angle measured with respect to at least one of the conductors **310A-310n**. In embodiments the conductors **320A-320n** included in the second plurality of conductors **320** may intersect the conductors **310A-310n** included in the first plurality of conductors **310** at an angle of approximately 90 degrees (i.e., each of the conductors **320A-320n** is orthogonal to each of the conductors **310A-310n**).

The conductors **320A-320n** may be formed using any conductive material including, but not limited to, metals (copper, aluminum, etc.), metal alloys (copper containing

alloys, aluminum containing alloys, etc.), conductive non-metals (polymers, conductive nanoparticle matrices, etc.) or any combination thereof. The conductors **320A-320n** may have any physical size, shape, geometry, and/or cross-sectional profile. The conductors **320A-320n** may be disposed or otherwise deposited in any uniform or non-uniform pattern including, but not limited to, straight lines, circles, arcs, polygons, or combinations thereof. The conductors **320A-320n** may be conductively coupled to support circuitry **140** formed in, on, about, or across the base die **130** using vias, metal traces, or similar electrically conductive structures. The conductors **320A-320n** may be conductively coupled to contact pads or similar electrically conductive features on the lower surface **134** of the base die **130** by one or more through silicon vias (TSVs).

At **908** a node on the electrical mesh network **110** is created at each point where a conductor **320** and a conductor **310** intersect or conductively couple. In embodiments, a plurality of nodes may be created by a plurality of intersections and/or conductive couplings between conductors **320A-320n** and conductors **310A-310n**. Each of the nodes creates a potential connection point for at least one IP core **120**. In embodiments, each node may have a single conductive coupling to the IP core **120** and/or the support circuitry **140** disposed in the base die **130**. In other embodiments, each node on the electrical mesh network **110** may have a plurality of conductive couplings to the IP core **120** and/or the support circuitry **140** disposed in the base die **130**. A node on the electrical mesh network **110** may therefore represent a conductive coupling that includes only a single connection or a conductive coupling that includes a plurality of connections.

At **910**, each of a plurality of IP cores **120** are conductively and physically coupled to respective ones of a plurality of nodes included in the electrical mesh network **110**. The method **900** concludes at **912**.

FIG. **10** is a high-level flow diagram of an illustrative method **1000** of coupling an electrical mesh network **110** disposed on at least a portion of an upper surface **132** of the base die **130** to one or more conductive structures **138** on the lower surface **134** of the base die **132**, in accordance with at least one embodiment described herein. The method **1000** may be used in conjunction with any of the methods **900**, **1100**, and **1200** described in detail with regard to FIGS. **9**, **11**, and **12**, respectively. The electrical mesh network **110** conductively couples to each of the IP cores **120** and also conductively couples to support circuitry **140** disposed in the base die **130**. In embodiments, the electrical mesh network **110** may be conductively coupled to the substrate **150** via the conductive structures **138** disposed on the lower surface **134** of the base die **130**. The method **1000** commences at **1002**.

At **1004**, through silicon vias (TSVs) **230** are formed through the base die **130**. The TSVs **230** conductively couple the electrical mesh network **110** to the conductive structures **138** disposed on the lower surface **134** of the base die **130**. In embodiments, one or more vias may additionally conductively couple some or all of the support circuitry **140** disposed in, on, or about the base die **130** to the conductive structures **138** disposed on the lower surface **134** of the base die **130**. The method **1000** concludes at **1006**.

FIG. **11** is a high-level flow diagram of an illustrative method **1100** of forming one or more active components and/or support circuitry **140** that includes one or more active components in a region or portion of the base die **130** proximate the upper surface **132** of the base die **130**, in accordance with at least one embodiment described herein. The method **1100** may be used in conjunction with any of the

methods **900**, **1000**, and **1200** described in detail with regard to FIGS. **9**, **10**, and **12**, respectively. In embodiments, the base die **130** may include support circuitry **140** accessed via the electrical mesh network **110** by the IP cores **120**. In embodiments, the support circuitry **140** may include, but is not limited to: input/output circuitry; data storage circuitry; voltage regulation circuitry; power distribution circuitry; cache storage circuitry; and combinations thereof. In embodiments, the support circuitry **140** may include active components such as transistors. The method **1100** commences at **1102**.

At **1104**, active components are deposited, formed, or otherwise disposed in a portion **220** of the base die **130**. In embodiments, the portion **220** may include a portion of the base die proximate the upper surface **132** of the base die. The active components may include one or more circuits containing active semiconductor components, such as transistors forming a portion of the support circuitry **140** conductively coupled to the electrical mesh network **110**. The method **1100** concludes at **1106**.

FIG. **12** is a high-level flow diagram of an illustrative method **1200** of forming one or more active components and/or circuitry that includes one or more active components in a region or portion of the IP core **120** proximate the lower surface **124** of the IP core **120**, in accordance with at least one embodiment described herein. The method **1200** may be used in conjunction with any of the methods **900**, **1000**, and **1100** described in detail with regard to FIGS. **9**, **10**, and **11**, respectively. In embodiments, the IP core **120** may include circuitry such as processor core circuitry or graphics processor circuitry. Positioning active components proximate the lower surface **124** of the IP core beneficially shortens the physical distance between circuitry disposed in, on, or about the IP core **120** and support circuitry disposed in, on, or about the base die **130**. Reducing the physical distance between the IP core circuitry and the support circuitry **140** may reduce power consumption and/or improve communication bandwidth. The method **1200** commences at **1202**.

At **1204**, active components are deposited, formed, or otherwise disposed in a portion **210** of the IP core **120**. In embodiments, the portion **210** may include a portion of the IP core **120** that is proximate the lower surface **124** of the IP core **120**. The active components may include one or more circuits containing active semiconductor components, such as transistors forming a portion of the functional circuitry of the IP core **120**.

At **1206**, the active components formed in the lower portion **210** of the IP core **120** are conductively coupled to the electrical mesh network **110**. The method **1200** concludes at **1206**.

While FIGS. **9**, **10**, **11**, and **12** illustrate various operations according to one or more embodiments, it is to be understood that not all of the operations depicted in FIGS. **9**, **10**, **11**, and **12** are necessary for other embodiments. Indeed, it is fully contemplated herein that in other embodiments of the present disclosure, the operations depicted in FIGS. **9**, **10**, **11**, and **12**, and/or other operations described herein, may be combined in a manner not specifically shown in any of the drawings, but still fully consistent with the present disclosure. Thus, claims directed to features and/or operations that are not exactly shown in one drawing are deemed within the scope and content of the present disclosure.

As used in this application and in the claims, a list of items joined by the term "and/or" can mean any combination of the listed items. For example, the phrase "A, B and/or C" can mean A; B; C; A and B; A and C; B and C; or A, B and C. As used in this application and in the claims, a list of items

joined by the term “at least one of” can mean any combination of the listed terms. For example, the phrases “at least one of A, B or C” can mean A; B; C; A and B; A and C; B and C; or A, B and C.

Any of the operations described herein may be implemented in a system that includes one or more mediums (e.g., non-transitory storage mediums) having stored therein, individually or in combination, instructions that when executed by one or more processors perform the methods. Here, the processor may include, for example, a server CPU, a mobile device CPU, and/or other programmable circuitry. Also, it is intended that operations described herein may be distributed across a plurality of physical devices, such as processing structures at more than one different physical location. The storage medium may include any type of tangible medium, for example, any type of disk including hard disks, floppy disks, optical disks, compact disk read-only memories (CD-ROMs), rewritable compact disks (CD-RWs), and magneto-optical disks, semiconductor devices such as read-only memories (ROMs), random access memories (RAMs) such as dynamic and static RAMs, erasable programmable read-only memories (EPROMs), electrically erasable programmable read-only memories (EEPROMs), flash memories, Solid State Disks (SSDs), embedded multimedia cards (eMMCs), secure digital input/output (SDIO) cards, magnetic or optical cards, or any type of media suitable for storing electronic instructions. Other embodiments may be implemented as software executed by a programmable control device.

Thus, the present disclosure is directed to systems and methods of conductively coupling a plurality of relatively physically small IP core dies to a relatively physically larger base die using an electrical mesh network that is formed in whole or in part in, on, across, or about all or a portion of the base die. The use of the electrical mesh network beneficially permits the positioning of the IP cores in close proximity to support circuitry carried by the base die. The minimal separation between the IP core circuitry and the support circuitry advantageously improves communication bandwidth while reducing power consumption. Each of the IP cores may include functionally dedicated circuitry such as processor core circuitry or graphics processing circuitry. The use of IP core dies beneficially and advantageously permits the use of a wide variety of IP cores, each having a common or similar interface to the electrical mesh network.

The following examples pertain to further embodiments. The following examples of the present disclosure may comprise subject material such as at least one device, a method, at least one machine-readable medium for storing instructions that when executed cause a machine to perform acts based on the method, means for performing acts based on the method and/or a system for providing an electrical mesh network that communicably couples a plurality of relatively small, limited function, IP cores to a relatively large base die that includes support circuitry for use by the IP cores.

According to example 1, there is provided a semiconductor package. The semiconductor package may include: a base die having an upper surface and a lower surface, the base die including input/output circuitry; an electrical mesh network disposed proximate the upper surface of the base die and conductively coupled to the input/output circuitry included in the base die, the electrical mesh network including: a first plurality of conductors wherein; each of the first plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining first plurality of conductors; and a second plurality of conduc-

tors, wherein: each of the second plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining second plurality of conductors; and each of the second plurality of conductors intersects and conductively couples to at least one of the first plurality of conductors; a plurality of IP cores, each of the plurality of IP cores including processor core circuitry, each of the IP cores conductively coupled to a node formed by an intersection of one of the first plurality of conductors with one of the second plurality of conductors.

Example 2 may include elements of example 1 where each of the first plurality of conductors is disposed orthogonally to at least one of the second plurality of conductors.

Example 3 may include elements of any of examples 1 or 2 where each of the first plurality of conductors is disposed orthogonally to each of the second plurality of conductors.

Example 4 may include elements of any of examples 1 through 3 where each of the first plurality of conductors intersects and conductively couples to each of the second plurality of conductors.

Example 5 may include elements of any of examples 1 through 4 where the base die comprises a plurality of through-silicon-vias (TSV)s that conductively couple at least one of: the electrical mesh network and the I/O circuitry to contact pads disposed on the lower surface of the base die.

Example 6 may include elements of any of examples 1 through 5 where the base die further includes at least one active element.

Example 7 may include elements of any of examples 1 through 6 where the at least one active element comprises at least one transistor disposed proximate the upper surface of the base die, the at least one transistor conductively coupled to the electrical mesh network.

Example 8 may include elements of any of examples 1 through 7 where each of the IP cores includes an upper surface and a lower surface; and each of at least some of the IP cores includes at least one transistor disposed proximate the lower surface of the respective IP core.

Example 9 may include elements of any of examples 1 through 8 where each of the first plurality of conductors comprises a plurality of conductors patterned on the upper surface of the base die.

Example 10 may include elements of any of examples 1 through 9 where each of the second plurality of conductors comprises a plurality of conductors patterned on the upper surface of the base die.

Example 11 may include elements of any of examples 1 through 10 where the base die further comprises at least one of: voltage regulator circuitry, controller circuitry, and memory circuitry.

Example 12 may include elements of any of examples 1 through 11 where the base die further comprises voltage regulator circuitry, the voltage regulator circuitry conductively coupled to the processor core circuitry included in at least one of the plurality of IP cores.

According to example 13, there is provided a method. The method may include: forming a first plurality of conductors proximate an upper surface of a base die; forming a second plurality of conductors proximate the upper surface of the base die, wherein: each of the first plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining first plurality of conductors; each of the second plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining second plurality of conductors; and each of the first plurality of conductors intersects and conductively

couples to at least one of the second plurality of conductors to form an electrical mesh network, the electrical mesh network conductively coupled to circuitry included in the base die; and conductively coupling each of a plurality of IP cores to a respective node formed by an intersection of one of the first plurality of conductors with one of the second plurality of conductors.

Example 14 may include elements of example 13 where forming a second plurality of conductors on the upper surface of the base die may further include: forming the second plurality of conductors on the upper surface of the base die such that each of the second plurality of conductors are disposed orthogonally to at least one of the first plurality of conductors.

Example 15 may include elements of examples 13 and 14 where forming a second plurality of conductors on the upper surface of the base die further comprises: forming the second plurality of conductors on the upper surface of the base die such that each of the second plurality of conductors are disposed orthogonally to each of the first plurality of conductors.

Example 16 may include elements of any of examples 13 through 15 where forming a second plurality of conductors on the upper surface of the base die further comprises: forming the second plurality of conductors on the upper surface of the base die such that each of the second plurality of conductors intersects and conductively couples to each of the first plurality of conductors.

Example 17 may include elements of any of examples 13 through 16, the method further comprising: forming, in the base die, a plurality of through-silicon-vias (TSV)s that conductively couple at least one of: the electrical mesh network and the I/O circuitry to contact pads disposed on the lower surface of the base die.

Example 18 may include elements of any of examples 13 through 17, the method further comprising: forming at least one active element proximate the upper surface of the base die.

Example 19 may include elements of any of examples 13 through 18 where forming at least one active element proximate the upper surface of the base die further comprises: forming at least one transistor proximate the upper surface of the base die.

Example 20 may include elements of any of examples 13 through 19, the method may further include: conductively coupling the at least one transistor to the electrical mesh network.

Example 21 may include elements of any of examples 13 through 20, the method may further include: forming at least one transistor proximate a lower surface of at least some of the plurality of IP cores; and conductively coupling each of the at least one transistors proximate the lower surface of at least some of the plurality of IP cores to the electrical mesh network.

Example 22 may include elements of any of examples 13 through 21 where forming a first plurality of conductors on an upper surface of a base die may further include: patterning each of the first plurality of conductors on the upper surface of the base die.

Example 23 may include elements of any of examples 13 through 22 where forming a second plurality of conductors on an upper surface of a base die may further include: patterning each of the second plurality of conductors on the upper surface of the base die.

Example 24 may include elements of any of examples 13 through 23, the method may further include: forming at least

one of: input/output (I/O) circuitry, voltage regulator circuitry, controller circuitry, and memory circuitry in the base die.

Example 25 may include elements of any of examples 13 through 24, the method may further include: forming input/output circuitry in the base die; and conductively coupling, via the electrical mesh network, the I/O circuitry in the base die to the processor core circuitry included in at least one of the plurality of IP cores.

According to example 26, there is provided an electronic device. The electronic device may include: a printed circuit board; and a semiconductor package conductively coupled to the printed circuit board, the semiconductor package including: a base die having an upper surface and a lower surface, the base die including input/output circuitry; an electrical mesh network disposed proximate the upper surface of the base die and conductively coupled to the circuitry included in the base die, the electrical mesh network including: a first plurality of conductors wherein; each of the first plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining first plurality of conductors; and a second plurality of conductors, wherein: each of the second plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining second plurality of conductors; and each of the second plurality of conductors intersects and conductively couples to at least one of the first plurality of conductors; a plurality of IP cores, each of the plurality of IP cores including processor core circuitry, each of the IP cores conductively coupled to a node formed by an intersection of one of the first plurality of conductors with one of the second plurality of conductors.

Example 27 may include elements of example 26 where each of the first plurality of conductors is disposed orthogonally to at least one of the second plurality of conductors.

Example 28 may include elements of any of examples 26 and 27 where each of the first plurality of conductors is disposed orthogonally to each of the second plurality of conductors.

Example 29 may include elements of any of examples 26 through 28 where each of the first plurality of conductors intersects and conductively couples to each of the second plurality of conductors.

Example 30 may include elements of any of examples 26 through 29 where the base die further comprises a plurality of through-silicon-vias (TSV)s to conductively couple at least one of: the electrical mesh network and the I/O circuitry to contact pads disposed on the lower surface of the base die.

Example 31 may include elements of any of examples 26 through 30 where the base die further comprises at least one active element.

Example 32 may include elements of any of examples 26 through 31 where the at least one active element comprises at least one transistor disposed proximate the upper surface of the base die, the at least one transistor conductively coupled to the electrical mesh network.

Example 33 may include elements of any of examples 26 through 32 where each of the IP cores includes an upper surface and a lower surface; and where each of at least some of the IP cores includes at least one transistor disposed proximate the lower surface of the respective second semiconductor die.

Example 34 may include elements of any of examples 26 through 33 where each of the first plurality of conductors comprises a plurality of conductors patterned on the upper surface of the base die.

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Example 35 may include elements of any of examples 26 through 34 where each of the second plurality of conductors comprises a plurality of conductors patterned on the upper surface of the base die.

Example 36 may include elements of any of examples 26 through 35 where the circuitry included in the base die further comprises at least one of: voltage regulator circuitry, controller circuitry, and memory circuitry.

Example 37 may include elements of any of examples 26 through 36 where the base die further comprises voltage regulator circuitry, the voltage regulator circuitry conductively coupled to the processor core circuitry included in at least one of the plurality of IP cores.

According to example 38, there is provided a system that includes: means for forming a first plurality of conductors proximate an upper surface of a base die; means for forming a second plurality of conductors proximate the upper surface of the base die, where: each of the first plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining first plurality of conductors; each of the second plurality of conductors disposed proximate the upper surface of the base die and spaced apart from the remaining second plurality of conductors; and each of the first plurality of conductors intersects and conductively couples to at least one of the second plurality of conductors to form an electrical mesh network, the electrical mesh network conductively coupled to at least the I/O circuitry included in the base die; means for conductively coupling each of a plurality of IP cores to a node formed by an intersection of one of the first plurality of conductors with one of the second plurality of conductors.

Example 39 may include elements of example 38 where the means for forming a second plurality of conductors proximate the upper surface of the base die may further include: means for forming the second plurality of conductors proximate the upper surface of the base die such that each of the second plurality of conductors are disposed orthogonally to at least one of the first plurality of conductors.

Example 40 may include elements of any of examples 38 and 39 where the means for forming a second plurality of conductors proximate the upper surface of the base die may further include: means for forming the second plurality of conductors proximate the upper surface of the base die such that each of the second plurality of conductors are disposed orthogonally to each of the first plurality of conductors.

Example 41 may include elements of any of examples 38 through 40 where forming a second plurality of conductors proximate the upper surface of the base die may further include: forming the second plurality of conductors on the upper surface of the base die such that each of the second plurality of conductors intersects and conductively couples to each of the first plurality of conductors.

Example 42 may include elements of any of examples 38 through 41 and the system may further include: means for forming, in the base die, a plurality of through-silicon-vias (TSVs) that conductively couple at least one of: the electrical mesh network and the I/O circuitry to contact pads disposed on the lower surface of the base die.

Example 43 may include elements of any of examples 38 through 42 and the system may further include: means for forming at least one active element proximate the upper surface of the base die.

Example 44 may include elements of any of examples 38 through 43 where the means for forming at least one active element proximate the upper surface of the base die may

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further include: means for forming at least one transistor proximate the upper surface of the base die.

Example 45 may include elements of any of examples 38 through 44 and the system may further include: means for conductively coupling the at least one transistor to the electrical mesh network.

Example 46 may include elements of any of examples 38 through 45 and the system may further include: means for forming at least one transistor proximate a lower surface of at least some of the plurality of IP cores; and means for conductively coupling each of the at least one transistors proximate the lower surface of at least some of the plurality of IP cores to the electrical mesh network.

Example 47 may include elements of any of examples 38 through 46 where the means for forming a first plurality of conductors proximate an upper surface of a base die may further include: means for patterning each of the first plurality of conductors on the upper surface of the base die.

Example 48 may include elements of any of examples 38 through 47 where the means for forming a second plurality of conductors on an upper surface of a base die may further include: means for patterning each of the second plurality of conductors on the upper surface of the base die.

Example 49 may include elements of any of examples 38 through 48 and the system may further include means for forming at least one of: input/output (I/O) circuitry, voltage regulator circuitry, controller circuitry, and memory circuitry in the base die.

Example 50 may include elements of any of examples 38 through 49 and the system may further include means for forming input/output circuitry in the base die; and means for conductively coupling, via the electrical mesh network, the I/O circuitry in the base die to the processor core circuitry included in at least one of the plurality of IP cores.

According to example 51, there is provided a semiconductor package. The semiconductor package and multiple dies may include: an electrical mesh network that includes: a first plurality of conductors; a second plurality of conductors, each of the second plurality of conductor intersecting at least one of the first plurality of conductors, forming a plurality of network nodes, each of the network nodes at an intersection of one of the first plurality of conductors with one of the second plurality of conductors; a base die including I/O circuitry conductively coupled to at least one of the plurality of nodes; and a plurality of IP cores, each of the plurality of IP cores including processor core circuitry; each of the plurality of IP cores conductively coupled to a respective one of the plurality of nodes.

Example 52 may include elements of example 51 where the base die includes an upper surface and a transversely opposed lower surface and where the first plurality of conductors and the second plurality of conductors are disposed on the upper surface of the base die.

Example 53 may include elements of any of examples 51 and 52 where each of the first plurality of conductors is disposed orthogonally to at least one of the second plurality of conductors.

Example 54 may include elements of any of examples 51 through 53 where of the first plurality of conductors is disposed orthogonally to each of the second plurality of conductors.

Example 55 may include elements of any of examples 51 through 54 where each of the first plurality of conductors conductively couples to each of the second plurality of conductors.

Example 56 may include elements of any of examples 51 through 55 where the base die further includes a plurality of

through-silicon-vias (TSVs) that conductively couple at least one of: the electrical mesh network and the I/O circuitry to contact pads disposed on the lower surface of the base die.

Example 57 may include elements of any of examples 51 through 56 where the base die further includes at least one active element.

Example 58 may include elements of any of examples 51 through 57 where wherein the at least one active element comprises at least one transistor disposed proximate the upper surface of the base die, the at least one transistor conductively coupled to the electrical mesh network.

Example 59 may include elements of any of examples 51 through 58 where each of the plurality of IP cores includes an upper surface and a transversely opposed lower surface; and where each of at least some of the IP cores includes at least one transistor disposed proximate the lower surface of the respective IP core.

Example 60 may include elements of any of examples 51 through 59 where each of the first plurality of conductors comprises a plurality of conductors patterned on the upper surface of the base die.

Example 61 may include elements of any of examples 51 through 60 where each of the second plurality of conductors comprises a plurality of conductors patterned on the upper surface of the base die.

Example 62 may include elements of any of examples 51 through 61 where the base die further comprises at least one of: voltage regulator circuitry, controller circuitry, and memory circuitry.

Example 63 may include elements of any of examples 51 through 62 where the circuitry included in the base die comprises voltage regulator circuitry, the voltage regulator circuitry conductively coupled to the processor core circuitry included in at least one of the plurality of IP cores.

The terms and expressions which have been employed herein are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described (or portions thereof), and it is recognized that various modifications are possible within the scope of the claims. Accordingly, the claims are intended to cover all such equivalents.

What is claimed:

**1.** A method, comprising:

forming a first plurality of conductors on an upper surface of a base die;

forming a second plurality of conductors on the upper surface of the base die, wherein:

each of the first plurality of conductors is disposed on the upper surface of the base die and is spaced apart from the remaining first plurality of conductors;

each of the second plurality of conductors is disposed on the upper surface of the base die and is spaced apart from the remaining second plurality of conductors; and

each of the first plurality of conductors intersects and conductively couples to at least one of the second plurality of conductors to form an electrical mesh network on the upper surface of the base die, the electrical mesh network conductively coupled to circuitry included in the base die;

conductively coupling each of a plurality of cores to a node formed by an intersection of one of the first plurality of conductors with one of the second plurality

of conductors, wherein each of the plurality of cores comprises processor core circuitry.

**2.** The method of claim 1 wherein forming a second plurality of conductors on the upper surface of the base die further comprises:

forming the second plurality of conductors on the upper surface of the base die such that each of the second plurality of conductors are disposed orthogonally to at least one of the first plurality of conductors.

**3.** The method of claim 1 wherein forming a second plurality of conductors on the upper surface of the base die further comprises:

forming the second plurality of conductors on the upper surface of the base die such that each of the second plurality of conductors are disposed orthogonally to each of the first plurality of conductors.

**4.** The method of claim 1 wherein forming a second plurality of conductors on the upper surface of the base die further comprises:

forming the second plurality of conductors on the upper surface of the base die such that each of the second plurality of conductors intersects and conductively couples to each of the first plurality of conductors.

**5.** The method of claim 1, further comprising:

forming, in the base die, a plurality of through-silicon-vias (TSVs) that conductively couple at least one of: the electrical mesh network and the I/O circuitry to contact pads disposed on the lower surface of the base die.

**6.** The method of claim 1, further comprising: forming at least one active element proximate the upper surface of the base die.

**7.** The method of claim 6, wherein forming at least one active element proximate the upper surface of the base die further comprises:

forming at least one transistor proximate the upper surface of the base die.

**8.** The method of claim 7, further comprising: conductively coupling the at least one transistor to the electrical mesh network.

**9.** The method of claim 1, further comprising: forming at least one transistor proximate a lower surface of at least some of the plurality of cores; and conductively coupling each of the at least one transistors proximate the lower surface of at least some of the plurality of cores to the electrical mesh network.

**10.** The method of claim 1:

wherein forming a first plurality of conductors on an upper surface of a base die further comprises: patterning each of the first plurality of conductors on the upper surface of the base die;

wherein forming a second plurality of conductors on an upper surface of a base die further comprises patterning each of the second plurality of conductors on the upper surface of the base die.

**11.** The method of claim 1, further comprising: forming at least one of: input/output (I/O) circuitry, voltage regulator circuitry, controller circuitry, and memory circuitry in the base die.

**12.** The method of claim 1, further comprising: forming input/output circuitry in the base die; and conductively coupling, via the electrical mesh network, the I/O circuitry in the base die to the processor core circuitry included in at least one of the plurality of cores.